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*National Asthma
Education Program*

Expert Panel Report

Executive Summary: Guidelines for the Diagnosis and Management of Asthma



U.S. DEPARTMENT OF HEALTH
AND HUMAN SERVICES
Public Health Service
National Institutes of Health

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National Asthma Education Program
Office of Prevention, Education, and Control
National Heart, Lung, and Blood Institute
National Institutes of Health
Bethesda, Maryland 20892

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Foreword

Asthma morbidity and mortality are on the rise. From 1980 to 1987, the prevalence rate of asthma in the United States increased 29 percent, and death rates for asthma as the first-listed diagnosis increased 31 percent. In 1988, asthma-related health care expenditures exceeded \$4 billion in the United States. Yet these changes are occurring at a time when scientific advances are improving our understanding of asthma and providing new therapies.

To help all health care professionals bridge the gap between research and practice, the Coordinating Committee of the National Asthma Education Program (NAEP) convened an expert panel. The charge was to develop guidelines to improve the detection and treatment of asthma.

Because asthma is a chronic disease with acute exacerbations, it requires continuous medical care. Treatment is based on four critical components:

- The use of objective measures of lung function to assess the severity of asthma and to monitor the course of therapy
- Comprehensive pharmacologic therapy designed to reverse and prevent the airway inflammation characteristic of asthma as well as to treat airway narrowing
- Environmental control measures to avoid or eliminate factors that induce or trigger asthma exacerbations, including consideration of immunotherapy
- Patient education that fosters a partnership among the patient, his or her family, and the clinician.

The *Guidelines for the Diagnosis and Management of Asthma* elaborates on each of these elements of care; this *Executive Summary* highlights the major recommendations of the expert panel report. The complete report provides critical background information, reference material, and discussion of specific considerations that will guide the clinician's adaptation and implementation of the recommendations.

In issuing these guidelines, the panel emphasizes that these are general guidelines developed to assist clinician and patient decisions about appropriate asthma care; specific therapeutic regimens must be tailored to individual needs and circumstances. The expert panel's recommendations represent a broad consensus because they are based upon review of the scientific literature, the expert judgement and collective opinion of the panel members, and review and approval by members of the Coordinating Committee of the National Asthma Education Program. However, these guidelines are not to be construed as either an official regulatory document or as a document that has been endorsed by the United States Food and Drug Administration.

People with asthma usually seek care from their primary care physician or nurse, who might then refer them to an asthma specialist. This report, therefore, is designed principally to provide these clinicians with new insights into asthma management. It is hoped that the report will also be of use to others involved in asthma care, including, among others, respiratory care therapists, health educators, social workers, and psychologists—and, of course, the asthma patient.

On behalf of the National Asthma Education Program Coordinating Committee and the National Heart, Lung, and Blood Institute, I would like to acknowledge the superb work of the expert panel and the outstanding leadership of its chair, Dr. Albert L. Sheffer. The development of this report was a challenging task, one that Dr. Sheffer and the panel members carried out with vigor, dedication, and a commitment to excellence.



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Definition and Diagnosis

Definition

Asthma is a lung disease with the following characteristics:

1. **Airway obstruction** (or airway narrowing) that is reversible (but not completely so in some patients) either spontaneously or with treatment

2. **Airway inflammation**

3. **Airway hyperresponsiveness** to a variety of stimuli.

Pathophysiology

Airway obstruction. Airway obstruction is responsible for the clinical manifestations of asthma such as wheezing, dyspnea, and cough. Airway narrowing may worsen gradually and persist despite therapy, but it can also develop abruptly and produce acute respiratory insufficiency.

Airflow obstruction, which is determined by the diameter of the airway lumen, can be influenced by a number of factors, including edema of the bronchial wall, mucus production, airway smooth muscle contraction, and hypertrophy. Airway obstruction is thought to be initiated by inflammatory events in the airways.

Airway inflammation. The airways of asthma patients are infiltrated by a number of different inflammatory cells,¹ which then cause complex interactions²⁻⁵ resulting in epithelial disruption⁶ and mucosal edema. An initial trigger in asthma may cause the release of inflammatory mediators from bronchial mast cells, macrophages, and epithelial cells.^{7,8} These substances cause the directed migration and activation of an inflammatory infiltrate composed predominantly of eosinophils and neutrophils. Leukotrienes are released and attract further cellular infiltrate. This process produces epithelial injury, abnormalities in neural mechanisms, increases in airway smooth muscle responsiveness,^{9,10} and airflow obstruction.^{9,10}

Epithelial injury can lead to increased permeability and sensitivity to inhaled allergens, irritants, and inflammatory mediators. In addition, transudation of fluids and reduced clearance of inflam-

matory substances and respiratory secretions occur with disruption of epithelium mucociliary mechanisms. The inflammatory process may chronically irritate the airway.

Airway hyperresponsiveness. Airway hyperresponsiveness is an exaggerated bronchoconstrictor response to many physical, chemical, and pharmacologic agents¹¹ (e.g., allergens, environmental irritants, viral respiratory infections, cold air, or exercise).

Whether airway hyperresponsiveness, an abnormality fundamental to the pathogenesis of asthma, is present at birth in genetically predisposed individuals, or whether it is acquired is a subject of current debate (although it is well known that individuals can develop asthma as a direct result of occupational exposures).

The level of airway hyperresponsiveness can be measured in the laboratory by standard inhalation challenge testing with methacholine or histamine as well as after exposure to nonpharmacologic stimuli.¹¹ In addition, fluctuations in morning and evening peak expiratory flow rates (PEFR) appear to reflect airway hyperresponsiveness.¹² The level of airway hyperresponsiveness usually correlates with the clinical severity of asthma¹³ and with medication requirements.¹⁴

Airway inflammation is thought to be a key factor in airway hyperresponsiveness, given the evidence suggesting the presence of airway inflammation in all asthma, including mild asthma. Furthermore, treatments that reduce bronchial inflammation in asthma patients appear to decrease the degree of airway hyperresponsiveness.^{1,6,9,14,15} Other mechanisms proposed to explain airway hyperresponsiveness, in addition to airway inflammation, are alterations in autonomic neural control of airways and changes in intrinsic bronchial smooth muscle function.

Pathophysiology of Exacerbations of Asthma

Exacerbations of asthma are acute or subacute episodes of progressively worsening shortness of breath, cough,

wheezing, chest tightness, or some combination of these symptoms. Exacerbations are characterized by decreases in expiratory airflow.

Airway smooth muscle contraction, which results in airway obstruction, is the primary abnormality in asthma. Other physiological changes also contribute to the clinical findings characteristic of asthma exacerbations:

■ Airways narrow because of bronchospasm, mucosal edema, and mucus plugging. Air is trapped behind narrowed small airways.

■ Functional residual capacity rises; hyperinflation¹⁶⁻¹⁸ helps keep airways open.

■ Accessory muscles (sternocleidomastoid) of respiration are used to maintain the lungs in a hyperinflated state.¹⁸

■ Hypoxemia occurs during severe exacerbations because of mismatching of ventilation and perfusion.

■ Pulmonary vascular resistance may increase due to hypoxemia and hyperinflation.

■ Negative pleural pressures become more negative as lung hyperinflation occurs; this is manifested by pulsus paradoxus.

The response of airways to an inhaled antigen demonstrates the pathogenesis of asthma and the mechanisms of airway hyperresponsiveness. When an asthma patient inhales an antigen, the immediate response is bronchoconstriction. In about half of asthma patients, the inhaled antigen also causes a delayed reaction 4 to 8 hours later. This late response is characterized by persistent airway obstruction, airway inflammation, and airway hyperresponsiveness.¹⁹ In the immediate response, mast cell degranulation and release of bronchospastic mediators are thought to be important.^{5,20} Mast cells participate in the late response by attracting other inflammatory cells to the airways. Of particular importance is the finding that there are increased numbers of eosinophils in the airways during the late response. Eosinophils

cause airway injury and alter epithelial function with mediator release.^{3,7} Other cells found in the airways during the late response (neutrophils, macrophages, basophils, and lymphocytes) also contribute to inflammation.

Diagnosis of Asthma

Diagnosis focuses on establishing episodic airway obstruction and the reversibility of the obstruction. A correct diagnosis of asthma is ensured when careful attention is given to the individual patient's pulmonary function and selected information from the medical history, physical examination, and laboratory test results. It is important to recognize that patients with asthma are heterogeneous and that they present signs and symptoms that vary widely from patient to patient as well as within each patient over time. The clinician needs to create an individualized, ongoing data base that will help assess the degree of severity of the patient's asthma, identify etiologic and aggravating factors, and plan an appropriate course of therapy.

Medical history. Topics to include in the history are outlined in Figure 1.

Physical examination. The physical examination for chronic asthma focuses on the upper respiratory tract, the chest, and the skin.

- Presence of rhinitis and/or sinusitis (e.g., purulent nasal discharge and postnasal discharge suggest sinusitis), nasal polyps.
- Evidence of hyperinflation of the lungs, particularly in children (e.g., use of accessory muscles, appearance of hunched shoulders and "pigeon chest").
- Quality of breath sounds. Wheezing is the characteristic breath sound of asthma, but it is not a reliable indication of severity. The intensity of the breath sounds in symptomatic asthma is typically reduced. A prolonged phase of forced expiration is typical of airflow obstruction.
- Flexural eczema.

Spirometry (see Component 1, Objective Measures) should be undertaken for all patients in whom the diagnosis of asthma is under consideration. This may be performed by primary care physicians or asthma specialists.

Additional studies may also be considered. No one test or set of tests is appropriate for every patient, however. Procedures to consider are:

- Complete blood count (CBC).
- Chest x-ray. (This can rule out other causes of airway obstruction. A recent x-ray is especially important for children.)
- Sputum examination and stain for eosinophilia. (Sputum eosinophilia are highly characteristic of asthma; neutrophils predominate in bronchitic sputum.)
- Nasal secretion and stain for eosinophils. (Neutrophilic nasal discharge is characteristic of sinusitis.)
- Complete pulmonary function studies, including inspiratory and expiratory flow volume curve. (These may reveal upper airway problems that simulate asthma.)
- Determination of specific IgE antibodies to common inhalant allergens with skin (in vivo) or in vitro tests. (Investigating the role of allergy in the patient's asthma is useful—see Component 3, Environmental Measures.)
- Rhinoscopy.
- Sinus x-rays.
- Bronchoprovocation with methacholine, histamine, or exercise challenge.
- Provocative challenge with occupational allergens (chemicals).
- Evaluation of pH for gastroesophageal reflux.

Differential diagnosis of asthma. Recurrent episodes of cough and wheezing are almost always due to asthma in both children and adults. Underdiagnosis of asthma is a frequent problem, and it occurs most often in young children who wheeze only when they have

respiratory infections and are dismissed as having bronchitis or pneumonia even though the signs and symptoms are most compatible with a diagnosis of asthma. However, the clinician needs to be aware of other causes of airway obstruction leading to wheezing. Among the many differential diagnostic possibilities, the most likely in infants, children, and adults are:

■ Infants and children

- Obstruction involving large airways
 - Foreign body in trachea, bronchus, or esophagus
 - Vascular rings
 - Laryngotracheomalacia
 - Enlarged lymph nodes or tumor
 - Laryngeal webs
 - Tracheostenosis or bronchostenosis
- Obstructions involving both large and small airways
 - Asthma
 - Viral bronchiolitis
 - Cystic fibrosis
 - Chlamydia trachomatis infection
 - Obliterative bronchiolitis
 - Bronchopulmonary dysplasia
 - Aspiration from swallowing mechanism dysfunction or gastroesophageal reflux
 - Vascular engorgement
 - Pulmonary edema

■ Adults

- Mechanical obstruction of the airways
- Laryngeal dysfunction
- Chronic bronchitis
- Pulmonary emphysema
- Congestive heart failure
- Pulmonary embolism
- Pulmonary infiltration with eosinophilia
- Cough secondary to drugs (beta blockers and/or angiotensin-converting enzymes [ACE] inhibitors)

The algorithm for decisionmaking in Figure 2 may be a useful guide in differential diagnosis.

General guidelines for referral to a specialist. Referral to a specialist in asthma care (usually an allergist or pulmonologist) is appropriate when:

- Patient has had a life-threatening acute asthma exacerbation, has poor self-management ability, or has difficult family dynamics.
- Signs and symptoms are atypical or there are problems in differential diagnosis (see above).
- Clinical entities complicate airway disease (e.g., sinusitis, nasal polyps, aspergillosis, severe rhinitis).
- Additional diagnostic testing is indicated (e.g., skin testing, rhinoscopy, bronchoscopy, complete pulmonary function studies, provocative challenge).
- Patient is not responding optimally to the asthma therapy.
- Patient requires guidance on environmental control, smoking cessation, complications of therapy, or difficult compliance issues.

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Figure 1 Medical History

Topics to include in the history are:

I. Symptoms

- A. Cough, wheezing, shortness of breath, chest tightness, and sputum production (generally of modest degree)
- B. Conditions known to be associated with asthma, such as rhinitis, sinusitis, nasal polypsis, or atopic dermatitis

II. Pattern of symptoms

- A. Perennial, seasonal, or perennial with seasonal exacerbations
- B. Continuous, episodic, or continuous with acute exacerbations
- C. Onset, duration, and frequency of symptoms (days per week or month)
- D. Diurnal variation with special reference to nocturnal symptoms

III. Precipitating and/or aggravating factors

- A. Viral respiratory infections
- B. Exposure to environmental allergens (pollen, mold, house-dust mite, cockroach, animal dander, or secretory product, e.g., saliva or urine)
- C. Exposure to occupational chemicals or allergens
- D. Environmental change (e.g., moving to a new home, going on a vacation, and/or alterations in workplace, work processes, or materials used)
- E. Exposure to irritants, especially tobacco smoke and strong odors, air pollutants, occupational chemicals, vapors, gases, and aerosols
- F. Emotional expressions: fear, anger, frustration, crying, hard laughing
- G. Drugs (aspirin, beta blockers, nonsteroidal anti-inflammatory drugs, others)
- H. Food additives (sulfites) and preservatives
- I. Changes in weather, exposure to cold air
- J. Exercise
- K. Endocrine factors (e.g., menses, pregnancy, thyroid diseases)

IV. Development of disease

- A. Age of onset, age at diagnosis
- B. Progress of disease (better or worse)
- C. Previous evaluation, treatment, and response
- D. Present management and response, including plans for managing acute episodes

V. Profile of typical exacerbation

- A. Prodromal signs and symptoms (e.g., itching of skin of the anterior neck, nasal allergy symptoms)
- B. Temporal progression
- C. Usual management
- D. Usual outcome

VI. Living situation

- A. Home age, location, cooling and heating (central with oil, electric, gas, or kerosene space heating), wood-burning fireplace
- B. Carpeting over a concrete slab
- C. Humidifier
- D. Description of patient's room with special attention to pillow, bed, floor covering, and dust collectors
- E. Animals in home
- F. Exposure to cigarette smoke, direct or sidestream, in home

VII. Impact of disease

- A. Impact on patient
 - 1. Number of emergency department or urgent care visits and hospitalizations
 - 2. History of life-threatening acute exacerbation, intubation, or oral steroid therapy
 - 3. Number of school or work days missed
 - 4. Limitation of activity, especially sports
 - 5. History of nocturnal awakening
 - 6. Effect on growth, development, behavior, school or work achievement, and lifestyle
- B. Impact on family
 - 1. Disruption of family dynamics, routines, or restriction of activities
 - 2. Effect on siblings and spouse
 - 3. Economic impact

VIII. Assessment of family's and patient's perception of illness

- A. Patient, parental, and spousal knowledge of asthma and belief in the chronicity of asthma and in the efficacy of treatment
- B. Ability of patient and parents or spouse to cope with disease
- C. Level of family support and patient and parents' or spouse's capacity to recognize severity of an exacerbation
- D. Economic resources

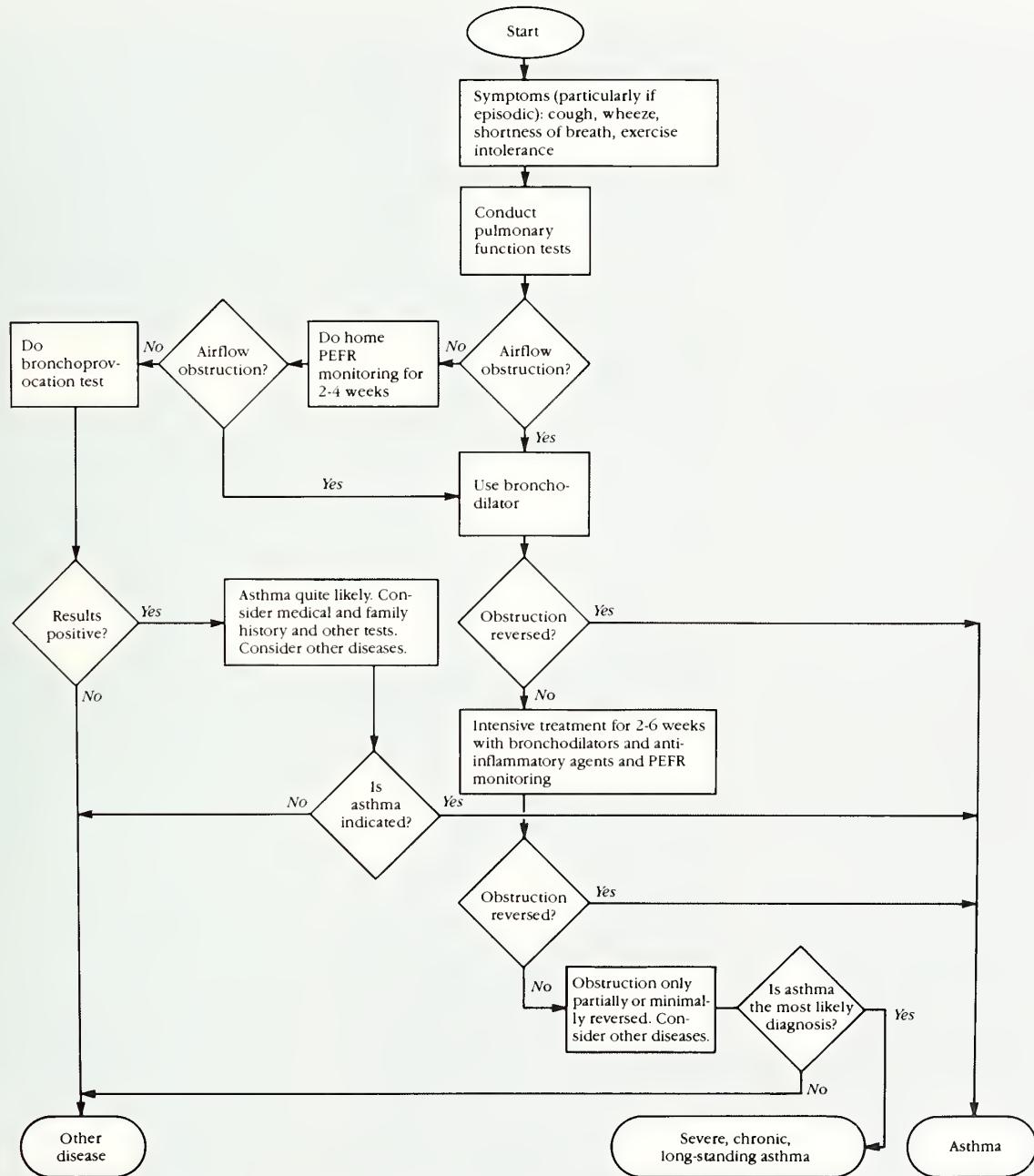
IX. Family history

- A. IgE-mediated allergy in close relatives
- B. Asthma in close relatives

X. Medical history

- A. General medical history and history of other allergic disorders (e.g., chronic rhinitis, atopic dermatitis, sinusitis, nasal polyps, gastrointestinal disturbances, adverse reactions to foods, drugs); in children, history of early life injury to the airways (e.g., bronchopulmonary dysplasia, history of pulmonary infiltrates, documented pneumonia, viral bronchiolitis, recurrent croup, symptoms of gastroesophageal reflux, passive exposure to cigarette smoke); in adults, cigarette smoking history
- B. Detailed review of symptoms

Figure 2
Algorithm for Diagnosing Asthma



Asthma is characterized by reversible airflow obstruction and can often be diagnosed with complete certainty. However, when mixed signals are present clinically, one must consider other diseases that can also cause airflow obstruction. Sometimes it may be impossible to distinguish among several possibilities or there may actually be coexisting diseases. This disclaimer is, in essence, true with any diagnosis.

The general approach for asthma is first to determine whether the patient has symptoms of cough, wheezing, shortness of breath, or exercise intolerance. Do they appear to be episodic in nature? If so, the diagnosis of asthma should be strongly considered, and efforts should be made to demonstrate with pulmonary function tests the reversibility of airflow obstruction after treatment. If airflow obstruction is present but does not immediately reverse with an inhaled bronchodilator, it may be necessary to treat the patient aggressively with bronchodilators and anti-inflammatory agents for up to 6 weeks before deciding that airflow obstruction is truly not reversible. If the symptoms present suggest asthma but there is no evidence of airflow obstruction, a bronchoprovocation should be performed. If the bronchial challenge is positive, then once again the diagnosis of asthma should be strongly considered.

At the point of strongly considering asthma, one should consider other diseases with reversible airflow obstruction, such as heart disease, the presence of foreign bodies in airways, and chronic obstructive pulmonary disease with a reversible component. If such diseases are present, and there are many to consider, one must try to determine whether this disease is predominant or whether asthma also coexists. When there is more than one disease present that can cause airflow obstruction, a conclusive diagnosis is difficult.

Modifying factors that increase the probability of asthma include such things as a personal or family history of asthma, hay fever, or other allergies. It should be remembered at this point, however, that there are two ages of onset of asthma. Asthma that begins in childhood almost always has a strong history of allergy and is likely to be atopic.

One final consideration: Some patients with severe, longstanding, and poorly treated asthma may develop irreversible airflow obstruction. These patients still may deserve a diagnosis of asthma if all other factors lead to that diagnosis, and if no other good cause for the airflow obstruction is found.

The Four Components of Asthma Management

Introduction

Effective management of asthma relies on four integral components: **objective measures of lung function** not only to assess but also to monitor each patient's asthma; **pharmacologic therapy**; **environmental measures** to control allergens and irritants; and **patient education**. Part Two describes these critical elements of asthma management.

Goals of Therapy

Effective management of asthma has the following goals:

- Maintain (near) "normal" pulmonary function rates.
- Maintain normal activity levels (including exercise).
- Prevent chronic and troublesome symptoms (e.g., coughing or breathlessness in the night, in the early morning, or after exertion).
- Prevent recurrent exacerbations of asthma.
- Avoid adverse effects from asthma medications.

General Treatment Principles

Encompassing all components of effective asthma management are the following general treatment principles:

- **Asthma is a chronic condition with acute exacerbations.** Treatment requires a continuous care approach in order to control symptoms, prevent exacerbations, and reduce chronic airway inflammation.
- **Prevention of exacerbations is particularly important.** This includes avoiding triggers and allergens, especially in the indoor environment. It also includes around-the-clock medication treatment for many patients. Periodic assessment of these patients, especially with objective measures, will assure that their therapy is appropriate.
- **The treatment of asthma should be based on an understanding of the underlying pathophysiologic mechanisms.** Asthma therapy should include efforts to reduce underlying

inflammation in asthma and to relieve or prevent symptomatic airway narrowing. Such efforts should lead to reduction in airway hyperresponsiveness and help prevent irreversible airway obstruction.¹⁴ The increased appreciation of the importance of inflammation in the pathogenesis of asthma has led to this greater emphasis on the use of anti-inflammatory medication as first-line asthma therapy.

- **Anticipatory or early interventions (facilitated by regular PEFR monitoring) in treating acute exacerbations of asthma reduce the likelihood of developing severe airway narrowing.**

Component 1 Objective Measures of Lung Function

Pulmonary function studies are essential for diagnosing asthma and for assessing the severity of asthma in order to make appropriate therapeutic recommendations. The use of objective measures of lung function is particularly important because subjective measures, such as patient symptom reports and physicians' physical examination findings, often do not correlate with the variability and severity of airflow obstruction.¹⁵

It is recommended that office spirometry be conducted in the initial assessment of all patients with, or being evaluated for, asthma and periodically thereafter as appropriate. Either spirometry or peak expiratory flow rate (PEFR) measured by a peak flow meter is recommended to assess the patient's response to therapy in the clinician's office, emergency department, and hospital. It is recommended that clinicians consider using home PEFR measurements to monitor the course of asthma and response to therapy in patients over 5 years old with moderate to severe asthma. For both spirometry and peak flow meter measurements, it is important to use correct techniques and equipment that meet established standards.^{6,7}

Spirometry

Pulmonary function is assessed by obtaining objective measurements of lung volumes or of flow rates produced with maximum expiratory effort. The most practical technique for obtaining these measurements is using a spirometer, which measures vital capacity, tidal volume, expiratory reserve volume, and inspiratory capacity. Most physicians' offices can successfully use an office spirometer. When office spirometry studies show abnormalities or complex questions arise, assessment in a specialized pulmonary testing facility should be considered.

Vital capacity is the most important measurement for assessing lung function. Measurements of flow rate then determine whether any reduction in vital capacity is due to restriction or obstruction. (Abnormalities of lung function are categorized as restrictive and obstructive defects. Specific disease processes are associated with each type. Restrictive defects are often associated with parenchymal lung disease or limitation of chest wall movement. Obstructive defects result from impairment of airflow through the trachea and bronchi leading from the alveolar sacs.) Flow rates may be measured directly or determined by noting the volume expired over a period of time. Timed volumes measured on a spirometer include:

- **Peak expiratory flow rate (PEFR):** The maximum flow rate that can be generated during a forced expiratory maneuver with fully inflated lungs. PEFR is measured in liters per second and requires maximum effort for accuracy.
- **Forced vital capacity (FVC):** Total volume of air expired as rapidly as possible.
- **Forced expiratory volume 1 second (FEV₁):** The volume of air expired in 1 second from maximum inspiration.
- **Maximum midexpiratory flow rate (MMEF):** The slope of line between 25 percent and 75 percent of the forced expiratory volume.

Clinical decisions can in many cases be made with the use of spirometry alone:

- A reduced vital capacity and a normal flow rate are consistent with restrictive defect. Occasionally, the FEV₁ is reduced concomitantly with the reduction of the vital capacity. The flow rate can then be determined by assessing the percentage of the FEV₁ over the FVC: If there is no obstruction, this ratio is greater than 75 percent, and with severe restriction, the rate will approach 90 percent.
- A normal vital capacity with either impaired FEV₁ or impaired MMEF indicates pure obstruction. When the FEV₁ is severely reduced with clear evidence of obstruction (FEV₁/FVC ratio of less than 75 percent), the vital capacity can also be reduced due to severe obstruction alone.
- When the question of a mixed restrictive and obstructive defect occurs, further studies are necessary.
- When the maximum midexpiratory flow rate is the only abnormal finding, mild airflow obstruction is present, suggesting small airway disease.

Peak Expiratory Flow Rate Measurement

PEFR provides a simple, quantitative, reproducible measure of airway obstruction that can be obtained using either standard office peak flow meters or inexpensive, portable peak flow meters. PEFR measurements, when done with a good effort, correlate well with FEV₁ measured by spirometry.^{8,9} PEFR is an objective measurement analogous to the measurement of blood pressure with a sphygmomanometer.

PEFR measurement is a valuable clinical tool in the office, emergency department, and inpatient hospital service for helping to assess degree of airflow obstruction and severity, for monitoring response to therapy, for diagnosing exercise-induced asthma, and for detecting asymptomatic deterioration.¹⁰⁻¹⁷ PEFR measurements, however, are not sufficient to make a diagnosis or

to fully evaluate physiologic impairment associated with asthma because PEFR is effort dependent and measures only large airway function.

When patients learn how to take PEFR measurements at home, the clinician's ability to provide effective treatment is improved. Daily monitoring of PEFR helps, for example, in detecting early stages of airway obstruction; assessing circadian (day-night) variations in lung function (which reflect degree of airway hyperresponsiveness);^{18,19} providing objective criteria in planning, initiating, or terminating treatment; facilitating communication between patient and clinician; and investigating specific allergens or school or workplace exposures that may exacerbate symptoms.²⁰⁻²⁵

Interpreting PEFR measurements. Because many patients' values are consistently higher or lower than average predicted norms (see Figure 3), it is important for each patient to establish a personal best PEFR value. This personal best value will be the standard against which subsequent measurements are evaluated by the patient and clinician. Personal best values can be established during a 2- to 3-week period in which the patient records PEFR measurements at least twice a day. The personal best is usually the highest PEFR measurement achieved in the p.m. measurement after a period of maximum therapy. A course of oral steroids may be needed to establish this personal best; and if the personal best is <80 percent of the predicted value, more aggressive therapy and continued daily monitoring are indicated. The personal best value should be reevaluated at least yearly to account for growth in children and progression of disease in children and adults. Further, peak flow meter measurements should be correlated periodically with office spirometry.

Using PEFR measurements at home to manage and monitor asthma. To integrate home PEFR monitoring into the treatment plan successfully, the clinician needs to explain how PEFR data are used to select and evaluate therapy. Regular supervision by the clinician is needed to ensure that the patient keeps PEFR

records up to date and takes appropriate action.

To help asthma patients use home PEFR monitoring, a system of PEFR zones may be useful.²⁶⁻²⁸ The zones can be established as a function of the patient's personal best or predicted value, whichever is highest. The emphasis is on the variability patients experience from their personal best or from one reading to the next rather than on isolated readings. It is recommended that daily measurements be made morning and evening—about 7 a.m. and 7 p.m. If the patient takes an inhaled medication, PEFR should be measured both before and after treatment. Taking PEFR measurements intermittently may lose the benefit of detecting early deterioration in lung function, but it may be preferred by some patients, particularly those with extremely stable asthma. If PEFR is measured only two or three times a week, both a.m. and p.m. readings on the same day are important.

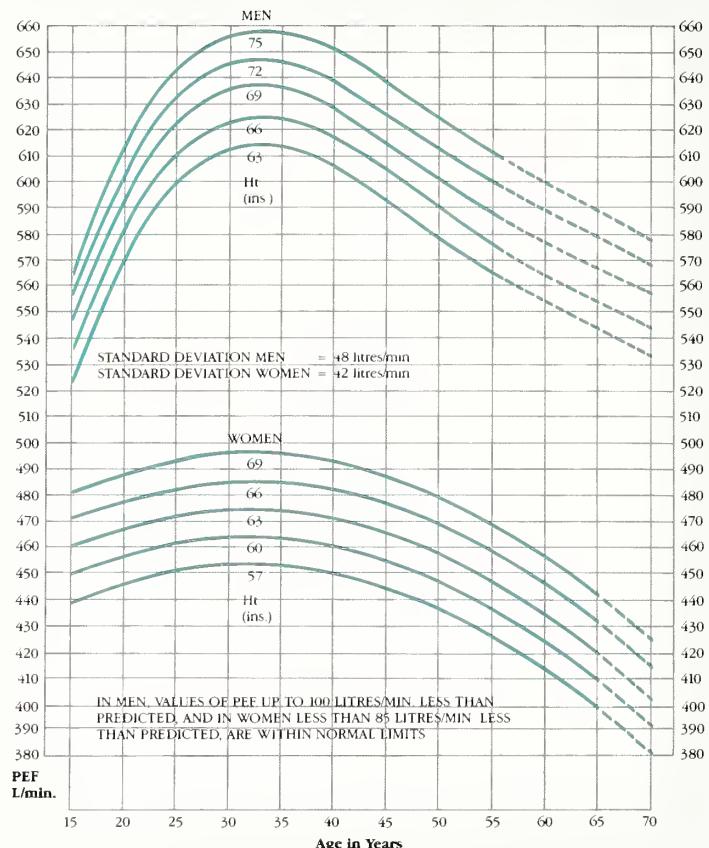
When the zone system is adapted to a traffic light system, it is may be easier to use and remember.^{26,27}

■ Green (80 to 100 percent of personal best) signals all clear: No asthma symptoms are present, and the routine treatment plan for maintaining control can be followed. For patients on chronic medications, consistent readings in the green zone may indicate an opportunity to consider a reduction in medications.

■ Yellow (50 to 80 percent of personal best) signals caution: An acute exacerbation may be present, and a temporary increase in medication may be indicated. Alternatively, the overall asthma may not be under sufficient control, and maintenance therapy may need to be increased.

■ Red (below 50 percent personal best) signals a medical alert: An immediate bronchodilator should be taken, and the clinician should be notified if PEFR measures do not return immediately and stay in yellow or green zones.

Figure 3
Sample Peak Expiratory Flow Rate Nomogram



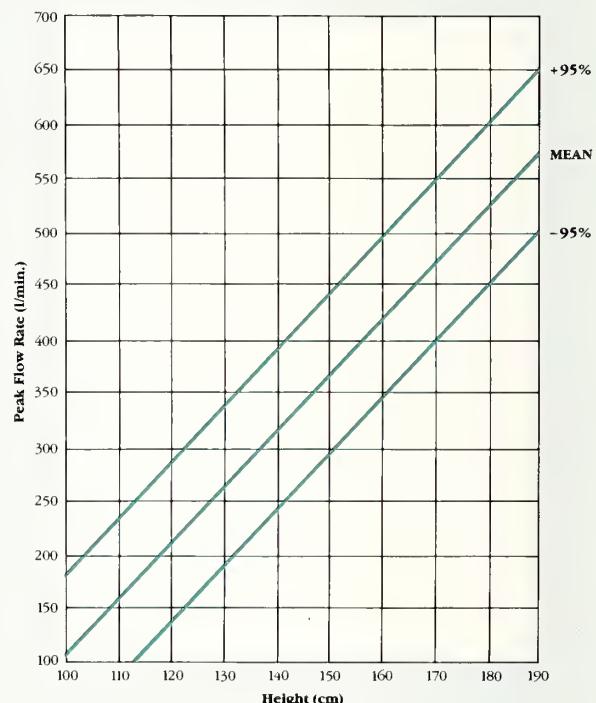
Adapted from: Nunn, AJ, Gregg, I, *Brit. Med. J.* 1989; 298:1068-70

Table 1
Predicted Average Peak Expiratory Flow for Normal Males

Age	(liters per minute)				
	60"	65"	70"	75"	80"
20	554	602	649	693	740
25	543	590	636	679	725
30	532	577	622	664	710
35	521	565	609	651	695
40	509	552	596	636	680
45	498	540	583	622	665
50	486	527	569	607	649
55	475	515	556	593	634
60	463	502	542	578	618
65	452	490	529	564	603
70	440	477	515	550	587

Adapted from: Leiner GC, et al: Expiratory peak flow rate. Standard values for normal subjects. Use as a clinical test of ventilatory function. *Am Rev Resp Dis* 88:644, 1963.

Note: These tables are averages and are based on tests with a large number of people. An individual's PEFR may vary widely. Further, many individuals' PEFR values are consistently bigger or lower than the average values. It is recommended that PEFR objectives for therapy be based upon each individual's "personal best," which is established after a period of PEFR monitoring while the individual is under effective treatment.



Adapted from: Godfrey S, et al., *Brit. J. Dis. Chest*, 1970; 64:15-24.

Table 2
Predicted Average Peak Expiratory Flow for Normal Females

Age	(liters per minute)				
	55"	60"	65"	70"	75"
20	390	423	460	496	529
25	385	418	454	490	523
30	380	413	448	483	516
35	375	408	442	476	509
40	370	402	436	470	502
45	365	397	430	464	495
50	360	391	424	457	488
55	355	386	418	451	482
60	350	380	412	445	475
65	345	375	406	439	468
70	340	369	400	432	461

Adapted from: Leiner GC, et al: Expiratory peak flow rate. Standard values for normal subjects. Use as a clinical test of ventilatory function. *Am Rev Resp Dis* 88:644, 1963.

Adapted from: Polger, G, Promedhat V: *Pulmonary function testing in children. Techniques and standards*. Philadelphia, W.B. Saunders, 1971.

These zones are guidelines only; there are insufficient data to definitively establish zones for optimal therapy. Specific zones should be tailored by the clinician in recognition of each individual patient's circumstances.

Component 2 Pharmacologic Therapy

Discussion of this component of asthma management is in four parts: the pharmacologic properties of the medications used; the protocols for management of asthma as a chronic illness; the protocols for management of exacerbations of asthma; and the protocol for management of exercise-induced asthma.

The Medications

Pharmacologic therapy is used to treat reversible airflow obstruction and airway hyperresponsiveness. Medications include bronchodilators and anti-inflammatory agents; some drugs may act as both.

Whatever medication is used, it is essential for both patient and clinician to recognize that a poor or short-lasting response to treatment in the face of progressively worsening asthma mandates immediate, intensive medical care. An increased use of bronchodilators or the lack of an expected therapeutic response to a medication may be indications of diminished control of asthma. In fact, recent data suggest that increased use of bronchodilators is associated with increased asthma morbidity and mortality.¹ A decreasing therapeutic response may develop over a short period of time, or gradually during a period of days. Failure to appreciate the severity of asthma or an inadequate response to therapy are major risk factors for morbidity and mortality during exacerbations of asthma.

Anti-inflammatory Agents

Anti-inflammatory agents interrupt the development of bronchial inflammation and have a prophylactic or preventive action. They may also modulate or

terminate ongoing inflammatory reactions in the airways. These agents include corticosteroids, cromolyn sodium or cromolyn-like compounds, and other anti-inflammatory compounds.

Corticosteroids. The most effective anti-inflammatory drugs for the treatment of reversible airflow obstruction are corticosteroids. The primary mechanisms of action are interference with arachidonic acid metabolism and synthesis of leukotrienes and prostaglandins, prevention of directed migration and activation of inflammatory cells, and increased responsiveness of beta-receptors of airway smooth muscle. Corticosteroids can be administered parenterally, orally, or as aerosols.^{2,3} Dosages are suggested in Figures 4, 8, and 9 (see pages 20, 27, and 34) and on the charts that accompany the discussions of asthma management in following sections.

Oral corticosteroid therapy. Using oral corticosteroids in the early treatment of severe exacerbations of asthma prevents progression of the exacerbation, decreases the need for emergency department visits or hospitalizations, and reduces the morbidity of the disease. When oral corticosteroids are used to treat acute asthma, the onset of action occurs approximately 3 hours after administration with peak effectiveness occurring approximately after 6 to 12 hours.⁴

Oral or parenteral corticosteroids are, however, associated with many adverse effects in both short- or long-term therapeutic use.

—*Short-term* major adverse effects include reversible abnormalities in glucose metabolism, increased appetite, fluid retention, weight gain, rounding of the face, mood alteration, hypertension, peptic ulcer, and aseptic necrosis of the femur.

—*Long-term* oral corticosteroid therapy is limited by the risk of significant adverse effects that include osteoporosis, hypertension,

Cushing's syndrome, cataracts, myopathy, hypothalamic-pituitary-adrenal axis suppression, and, in rare instances, impaired immune mechanisms. Prolonged daily use of oral corticosteroids should thus be reserved for patients with severe asthma (despite use of high doses of inhaled corticosteroids).

Attempts to reduce dependence on oral corticosteroids should be made. For any patient requiring chronic therapy, a trial should be conducted to determine if the oral corticosteroids can be reduced or eliminated by the use of high-dose (two to four times the usual daily dose) inhaled corticosteroids. Other therapeutic regimens to reduce oral corticosteroid dependence—using troleandomycin, methotrexate, and gold—are still experimental and should be used only in selected patients under the supervision of an asthma specialist.

Inhaled corticosteroid therapy. Inhaled corticosteroids are safe and effective for the treatment of asthma.⁵⁻⁸ Because of the importance of airway inflammation in the pathogenesis of asthma, inhaled corticosteroids are being used as primary therapy for moderate and severe asthma. This approach not only provides symptomatic benefit but also reduces airway hyperresponsiveness.⁵⁻⁹ Dosages are suggested in Figures 4, 8, and 9 and the charts accompanying the discussions of asthma management in the following sections.

Concentrations per inhalation vary among the corticosteroid formulations beclomethasone, triamcinolone, and flunisolide. In the absence of complete data, the guidelines for total dosage may be applied. However, the relative anti-inflammatory, steroid-suppressive effects of these three distinct formulations have not been established.

Systemic adverse effects because of inhaled corticosteroid therapy are infrequent at doses currently approved in the United States. Long-term high-dose regimens of inhaled corticosteroids are being utilized, and long-term followup studies are under way. Local adverse effects of inhaled corticosteroid therapy

include oropharyngeal candidiasis, dysphonia, and occasional coughing resulting from upper airway irritation caused by inhaling the corticosteroid aerosol,¹⁰ but these adverse effects can be reduced or prevented by administering corticosteroids with a chamber or spacer and by rinsing the mouth after each use.

Cromolyn sodium. Administered prophylactically, cromolyn sodium inhibits early- and late-phase allergen-induced airway narrowing as well as acute airway narrowing after exercise and after exposure to cold dry air and sulfur dioxide. The mechanism of action is not fully understood, but it is considered that cromolyn sodium stabilizes and prevents mediator release from mast cells. Whether a patient will respond to cromolyn sodium can not be reliably predicted. A 4- to 6-week trial therapy may be required to determine efficacy in individual patients.^{14, 8, 16} Cromolyn sodium produces only minimal side effects, such as occasional coughing upon inhalation of the powder formulation.

Other anti-inflammatory compounds. Drugs that are being tested in clinical trials but not yet approved for the treatment of asthma in the United States include nedocromil sodium (which, *in vitro*, inhibits mediator release and inhibits and modulates allergen-induced hyperresponsiveness), antihistamines (which block acute bronchoconstrictor effects produced by inhaled histamine and *in vitro* may inhibit mediator release), and ketotifen (which has antihistaminic activity).

Bronchodilators

Bronchodilators act principally to dilate the airways by relaxing bronchial smooth muscle. They include beta-adrenergic agonists, methylxanthines, and anticholinergics.

Beta-adrenergic agonists (beta₂-agonists). Beta₂-agonists relax airway smooth muscle and may modulate mediator release from mast cells and basophils.^{17, 18} The desirable effects of beta-adrenergic agonists in asthma

result from their action on beta₂-adrenergic receptors.

Inhaled beta₂-agonists are the medication of choice for treatment of acute exacerbations of asthma and for the prevention of exercise-induced asthma. Beta₂-agonists are also used chronically to aid in the control of persistent airway narrowing, although a recent report associates prolonged, regular administration (as opposed to as-needed use) of a potent inhaled beta₂-agonist with diminished control of asthma.¹ Therefore, exceeding three to four doses of inhaled beta₂-agonist on a daily regularly scheduled basis is not recommended.

Because asthma is an airway disease, inhaled beta₂-agonist therapy delivered directly to the airway is usually preferable to systemic oral therapy. Inhaled beta₂-agonist therapy, as compared to oral beta₂-agonist therapy, produces more bronchodilation; causes fewer systemic adverse effects such as cardiovascular stimulation, anxiety, and skeletal muscle tremor (although patients with preexisting cardiovascular disease, particularly the elderly, continue to be more likely to experience adverse cardiovascular reactions with inhaled therapy^{19, 20}); has a faster onset of action and similar duration of action; and achieves desired results at lower doses. Inhaled beta₂-agonists are available in metered-dose inhalers, dry-powder capsules, and compressor-driven nebulizers.

Methylxanthines. Theophylline is the principal methylxanthine used in asthma therapy. Although the precise mechanism is not clear (*in vitro* theophylline inhibits phosphodiesterases), theophylline serves as a mild-to-moderate bronchodilator, depending upon serum concentration.^{21, 22} When given in a sustained-release preparation, it has long duration of action and is thus particularly useful in the control of nocturnal asthma. When used in combination with usual doses of inhaled beta₂-agonists, theophylline may produce additional bronchodilation. In addition, theophylline may also reduce respiratory muscle fatigue²³ and possess some degree of anti-inflammatory activity.^{24, 25}

Theophylline has the potential for significant adverse effects, but these can generally be avoided by appropriate dosing and monitoring:

■ **Dosages** are suggested in Figures 4, 8, and 9 and on the charts accompanying the discussions of asthma management in the following sections. An optimal effect is produced by dosages that maintain a steady-state serum concentration of between 10 and 20 µg/mL. A more conservative approach is to aim for levels between 5 and 15 µg/mL,^{26, 27} a therapeutic range in which there appears to be a linear relation between log serum concentration and bronchodilator effect.

■ **Monitoring** of theophylline serum concentrations should be conducted when an asthma patient begins theophylline therapy and then at regular intervals of 6 to 12 months thereafter. It is also required when patients develop an adverse effect on their usual dose, when patients fail to exhibit the expected bronchodilator effect from an appropriate therapeutic regimen, when higher therapeutic levels are desired, and when conditions known to alter theophylline metabolism exist (see below).

Among points important to consider in relation to the use of theophylline are the following:

■ **Theophylline is eliminated from the body rapidly by some individuals**, especially children; sustained-release preparations are needed for chronic therapy.^{26, 28} Further, because preparations vary in intestinal transit time and in how they are affected by the presence of food (and its fat content) in the gut, physicians need to be familiar with the pharmacologic properties of the preparation selected in order to ensure efficacy.

■ **Theophylline clearance is reduced by several factors**, such as febrile illness, liver disease, congestive heart failure, and certain drugs (including cimetidine, quinolone, antibiotics, troleandomycin, and, to a lesser extent, erythromycin). These may reduce the elimination rate and allow toxic concentrations to develop. The dose of theophylline should be reduced in patients affected by these factors.

The signs and symptoms of theophylline intoxication involve many different organ systems. Serum concentrations under 15 µg/mL are generally not associated with theophylline toxicity. Gastrointestinal symptoms—nausea and vomiting—are the most common early events of toxicity. Seizures may occur that are not preceded by evidence of central nervous system stimulation. Children may experience behavioral disturbances because of central nervous system stimulation; however, a Food and Drug Administration review has concluded that current data do not support some earlier reports of theophylline's adverse effect on the learning of school children.²⁹ Cardiopulmonary effects include tachycardia, arrhythmias, and, occasionally, stimulation of the respiratory center (tachypnea). Diuresis and relaxation of the detrusor muscle (causing difficulty in urination in older men with prostatism) may occur. Important metabolic effects such as hyperglycemia and hypokalemia may also occur.

Anticholinergics. Inhaled anticholinergic agents produce bronchodilation by reducing intrinsic vagal tone to the airways. Such agents also block reflex bronchoconstriction caused by inhaled irritants. However, anticholinergic agents such as atropine have lost favor because of the length of time for onset of action and because of such local and systemic adverse effects as drying of respiratory secretions, blurred vision, and cardiac and central nervous system stimulation. Ipratropium is a quaternary derivative whose development has stimulated new interest in anticholinergic therapy.³⁰ Because of its very low bioavailability when inhaled, it lacks atropine's side effects. Some reports show it is effective during status asthmaticus when used in nebulized form in combination with beta₂-agonists.^{31,32} Its benefits in day-to-day management of asthma have not yet been established.

Management of Chronic Asthma

General Principles of Management

Treat the underlying pathology of asthma. Therapy should not merely alleviate symptoms but also prevent exacerbations and control chronic symptoms by reducing inflammation. First-line therapy should focus on preventing or reversing the airway inflammation that is a principal factor in the airway hyperresponsiveness that characterizes asthma and determines symptoms, disease severity, and possibly mortality.

Tailor general therapy guidelines to individual patient needs. Asthma is a disease that varies among patients. Further, the degree of severity for any individual may change from one season or year to the next. Therefore, specific asthma therapy—dictated by the severity of disease, medication tolerance, and sensitivity to environmental allergen—must be selected to fit the needs of individual patients.

The severity of asthma is often not appreciated by either patient or clinician on routine evaluation. However, by determining the extent to which activity is limited, by evaluating nighttime symptoms, and by assessing pulmonary function (by both spirometry and peak flow determinations), the clinician will be better able to begin appropriate therapy for a patient.

Treat asthma triggers, associated conditions, and special problems. Consideration of common asthma triggers is essential.

—Exposure to known *allergens and irritants* must be reduced or eliminated (see Component 3, Environmental Measures).

—*Viral upper respiratory syndromes* can provoke exacerbations of asthma, especially in young children. Although there is no specific therapy, patients and parents of patients need to be vigilant in adhering to the regular asthma medication treatment plans and in being alert for early signs of

an acute exacerbation so that asthma medication may be started or increased immediately. Some patients, especially children, have an established pattern in which asthma deteriorates rapidly every time they have a viral respiratory infection. For these selected patients, it may be appropriate to institute a short course of oral corticosteroid therapy at the earliest sign of viral respiratory infection.

—*Bacterial otitis and sinusitis* may be associated factors for asthma for all age groups. Even aggressive asthma therapy may fail if such infections are overlooked.

Antimicrobial therapy (for 10 days to 3 weeks, depending on the chronicity of the patient's history of ear or sinus disease) is necessary if a bacterial infection is present in the airways, although it remains an adjuvant to primary asthma therapy.

—*Influenza vaccinations and pneumococcal vaccine* should be considered for patients with moderate or severe asthma in order to avoid aggravation of asthma.

—*Allergic and nonallergic rhinitis* should be treated with antihistamines, cromolyn sodium nasal spray, or topical nasal corticosteroids.

—*Treatment of a known trigger prior to exposure*, with inhaled beta₂-agonist or cromolyn sodium or both, can prevent or diminish an asthmatic response. This is well demonstrated in relation to exercise (see the Exercise-Induced Asthma section). The same principles can be applied to other situations, including exposure to antigens (e.g., animal dander), cold air, or other irritants. However, because beta-agonists block symptoms during exposure, their use before antigen exposure may lead the patient to remain longer in the contaminated environment and increase the likelihood of symptoms occurring 4 to 6 hours later.

Cromolyn sodium taken before antigen exposure will block this late reaction to antigen as well as the immediate response.

—*Seasonal asthma* occurs in those patients who experience asthma only in relationship to such environmental allergens as pollens, molds, and house-dust mites.

Treatment for these individuals can be similar to that of other patients, depending upon the severity of asthma symptoms. If the patient has seasonal asthma on a predictable basis, prophylactic antiasthma therapy should be initiated prior to the anticipated onset of symptoms.

—*Cough variant asthma* is seen in some patients, especially young children. Cough is the principal symptom: because this frequently occurs at night, examinations during the day may be normal. Nocturnal administration of bronchodilators will often be therapeutic and diagnostic.

■ **Seek consultation with an asthma specialist** for pulmonary function studies, evaluation of the role of allergy and irritants, or evaluation of the medication plan if the goals of therapy are not achieved.

■ **Use step-care pharmacologic therapy.** An aim of therapy is to use the optimum medication needed to maintain control with minimal risk for adverse effects. The step-care approach, in which the number of medications and frequency of administration are increased as necessary, is used to achieve this aim.

—In general, every asthma patient must have an inhaled beta₂-agonist available for rescue treatment of acute symptoms. This rescue treatment itself has a step-care pattern: medications are added as necessary to control symptoms. The increase is often temporary and depends on the severity and duration of the asthma exacerbation as well as the patient's response. (Note, however, that increasing use of rescue treatment by the patient is an indication to review the medication plan and

possibly to increase preventive therapy.)

—Maintenance therapy, or chronic management of asthma, also uses a step-care approach and is based upon severity of disease: mild, moderate, or severe (see Charts 2-7). (For Chart 1, which illustrates the overview of therapy, see the full report.)

■ **Monitor continually.** Continual monitoring, which includes objective measures of assessment, is necessary to assure that therapeutic goals are met.

—While the patient is achieving control of asthma, PEFR variability greater than 10 to 20 percent and continued presence of chronic symptoms indicate a need to reevaluate the patient's technique in using medication, any environmental aggravators and the patient's efforts to control them, the possibility of concomitant upper respiratory disease, and, finally, the possibility that medications need to be increased.

—Once control is established, regular followup visits (at 1- to 3-month intervals) continue to be essential: clinicians need to monitor and review the treatment plans, the medications, and the patients' management techniques (i.e., for using medicines and peak flow meters, for controlling the environment).

—When control is sustained, that is, when PEFR variability is less than 10 percent and there are no asthma symptoms for a reasonable period (2 to 3 days for the exacerbation in mild asthma, several weeks for chronic moderate or severe asthma), reduction—or step-down—therapy can be carefully considered.

Protocol for Management of Asthma in Adults

Treatment plans for adult asthma are based on the goals of therapy, the general principles for managing asthma, and the appropriate roles of medication.

This section and its accompanying charts present application of these principles to development of treatment protocols based on the severity of disease.

Mild Asthma (Chart 2)

Inhaled beta₂-agonists by themselves are usually sufficient therapy for mild, episodic asthma. If symptoms disappear and pulmonary function normalizes with inhaled beta₂-agonists, they can be used indefinitely on an as-needed basis. However, their use more than three or four times a day—or even their daily use—usually indicates a need for additional therapy (see Moderate Asthma).

Oral theophylline does not usually give prompt bronchodilation; its use is recommended for continuous rather than episodic therapy.

Moderate Asthma (Chart 3)

The category of moderate asthma includes those patients who have symptoms that are not controlled or that are poorly regulated by episodic administration of a beta₂-agonist. Some patients have frequent (more than twice a week) symptomatic exacerbations of asthma. Other patients do not have acute exacerbations and can regulate symptoms by modulation in lifestyles, but their pulmonary functions (FEV₁ or PEFR 60 to 80 percent of predicted range) indicate compromises in airway function. These patients have very "fragile" control of asthma. Many asthma specialists think that all patients with moderate asthma should receive inhaled anti-inflammatory medication to diminish airway inflammation and airway hyperresponsiveness.

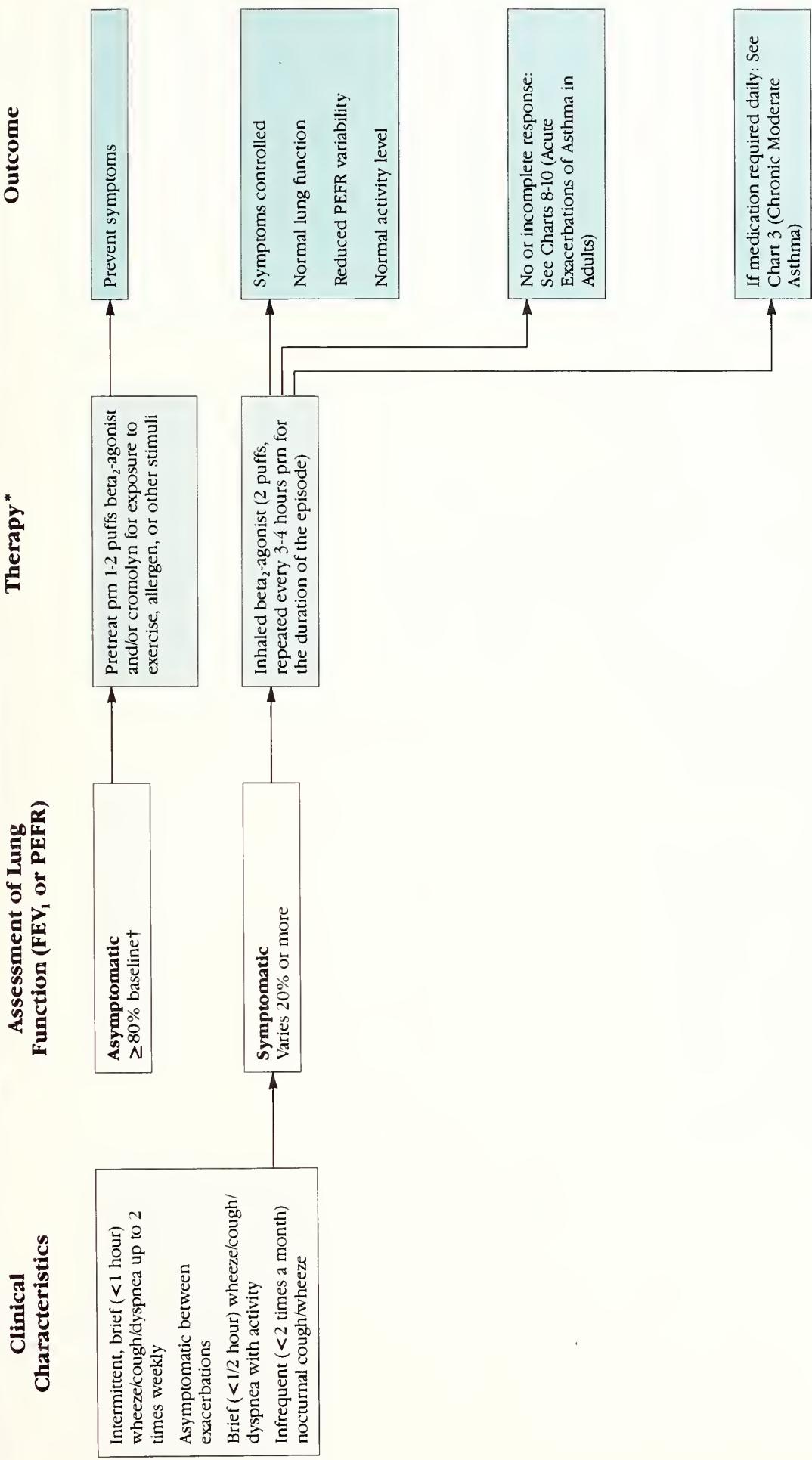
■ **Bronchodilators.** The physician has several choices:

—*As-needed (PRN) inhaled beta₂-agonist* must be available for treatment of acute exacerbations.

—*Regular administration of inhaled beta₂-agonists* is often effective. However, as noted in the Medications section, there is some evidence that prolonged use may be associated with diminished control of asthma. Thus, if the

Management of Asthma in Adults

Chronic Mild Asthma



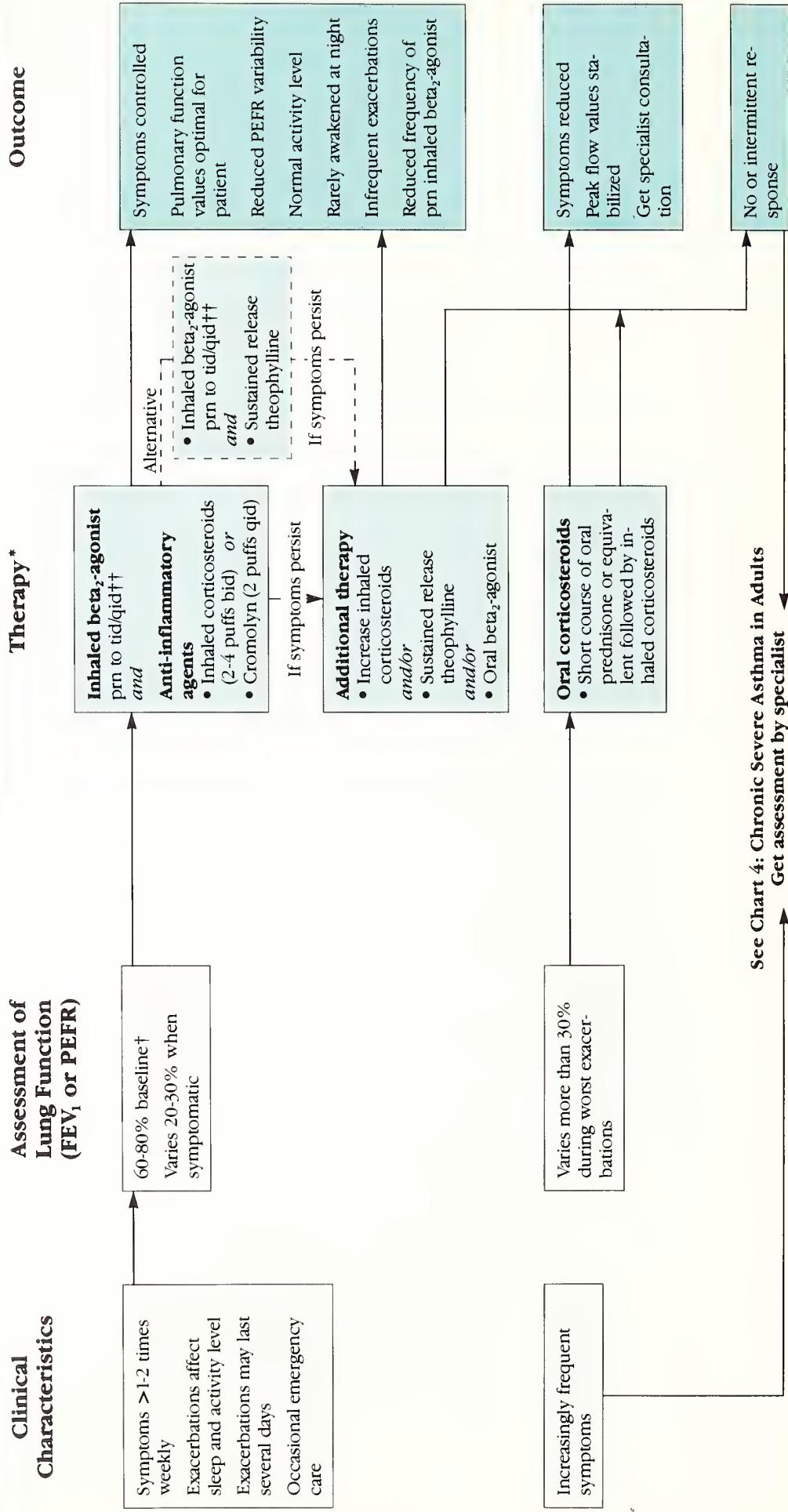
†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted of standardized norms or % patient's personal best.

*All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.

Chart 3

Management of Asthma in Adults

Chronic Moderate Asthma



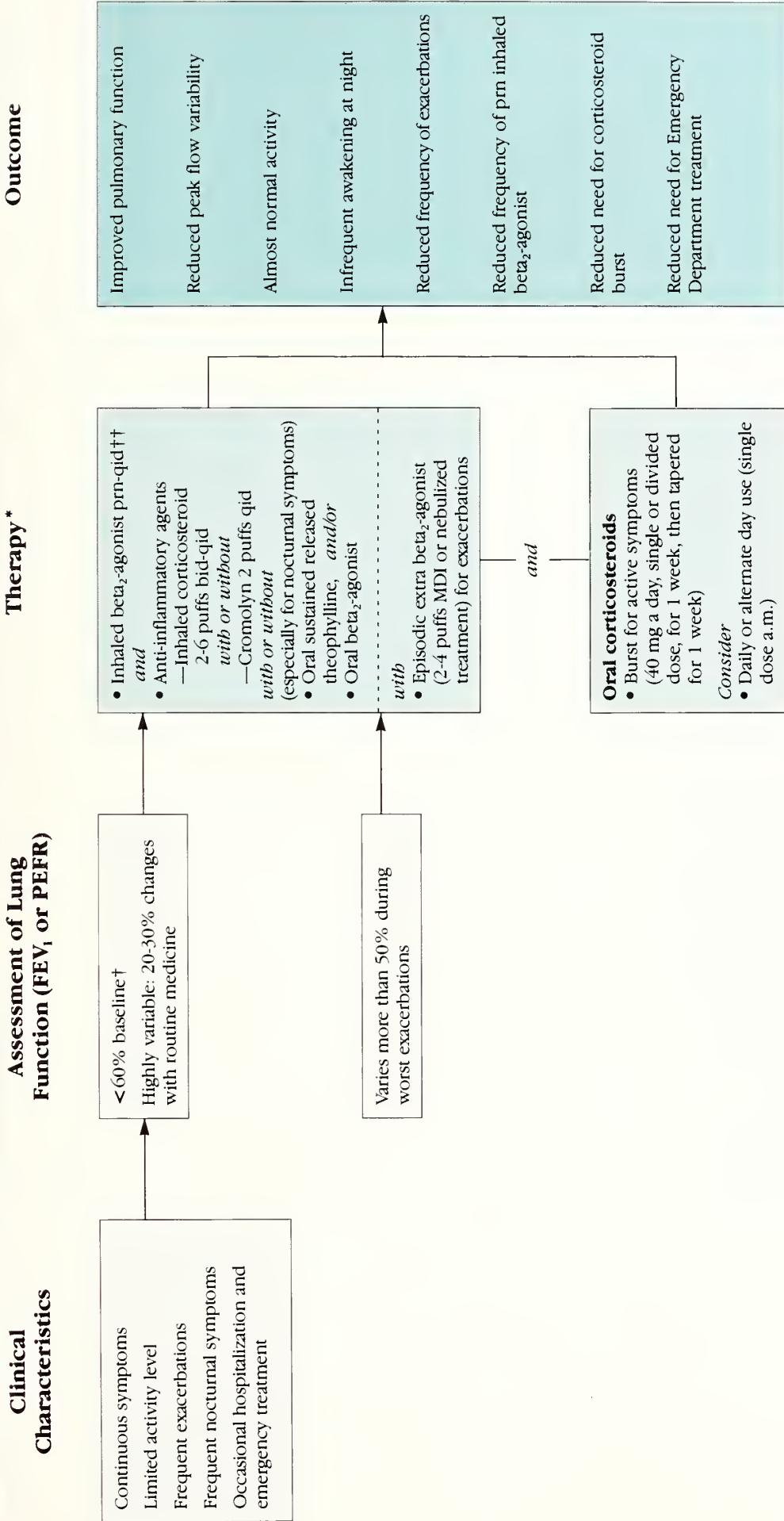
[†]PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted based on standardized norms or % patient's personal best.

^{††}If exceed 3-4 doses a day, consider additional therapy other than inhaled beta₂-agonist.

***All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.**

Management of Asthma in Adults

Chronic Severe Asthma



Note: Individuals with severe asthma should be evaluated by an asthma specialist.

†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted of standardized norms or % patient's personal best.

††If exceed 3-4 doses a day, consider additional therapy other than inhaled β_2 -agonist.

***All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.**

patient exceeds three to four doses a day of beta₂-agonist, other, additional therapy should be considered.

—*Sustained-release theophylline or long-acting oral beta₂-agonist* once a day in the evening may be helpful for the patient with primarily nocturnal symptoms because the currently available inhaled beta₂-agonists have a limited duration of action—4 to 6 hours. However, when patients who use sustained-release theophylline (or oral beta₂-agonist) to control nocturnal symptoms also take anti-inflammatory medication, they may be able to discontinue bronchodilator usage after 4 to 6 weeks.

If theophylline is the primary bronchodilator, beta₂-agonist therapy can be administered episodically.

■ **Anti-inflammatory agents** are the primary therapy in moderate asthma.

—*Inhaled corticosteroids* provide improved asthma care with minimal side effects. For example, in Europe and Australia, experience indicates that high doses (e.g., 1,600 to 2,600 µg beclomethasone per day) suppress airway hyperresponsiveness. Smaller doses (400 to 800 µg) may achieve similar effects in milder cases. Immediate benefit will not be evident, however, because suppression of symptoms and PEFR improvement are often not maximal until 2 to 4 weeks of treatment.

—*Cromolyn sodium* is virtually devoid of side effects and is the best nonsteroidal anti-inflammatory drug currently available. Its effectiveness, however, is less predictable than that of inhaled corticosteroids.

—*A burst, or short tapering course, of oral corticosteroids* is indicated when asthma is not controllable by any combination of bronchodilators, cromolyn sodium, or

inhaled corticosteroids, even at increased doses. Such deterioration of asthma is characterized by gradual reductions in PEFR (approximately 20 percent) that fail to have a sustained response to inhaled bronchodilators, by greater intolerance of activities or exercise, and by the development of nocturnal symptoms. A short course of, for example, 40 mg prednisone per day (single or divided dosing) for 1 week followed by 7 to 14 days of tapering doses may be effective. At the end of this therapeutic deescalation, oral corticosteroids can be stopped; if asthma symptoms do not occur and pulmonary functions remain normal, no additional therapy is necessary. However, if the burst of prednisone does not control symptoms, is effective for less than 10 to 24 days, or is repeated frequently, the patient has severe asthma and obviously needs additional therapy.

Severe Asthma (Chart 4)

Patients with severe asthma should be evaluated by an asthma specialist.

Patients whose asthma is not controlled on maximal doses of bronchodilators and inhaled anti-inflammatory agents need systemic corticosteroids on a routine basis. In such cases, the physician is tied to the use of long-term oral corticosteroids.

■ The lowest possible dose (alternate day or single daily dose) should be used and administered under the supervision of an asthma specialist.

■ Patients must be monitored closely for corticosteroid adverse side effects (see Medications section).

■ Attempts to reduce oral corticosteroids with persistent administration of high doses of inhaled steroids (e.g., 800 µg or more per day) should be made continually. Use of a spacer with these inhaled corticosteroids may help prevent oral candidiasis.

Protocol for Management of Asthma in Children

The treatment plans for children are also based on the goals of therapy, the general principles, and the appropriate roles of medication described earlier. Charts 5, 6, and 7 accompany the discussion here, and Figure 4 summarizes information on dosages for treatment of childhood asthma.

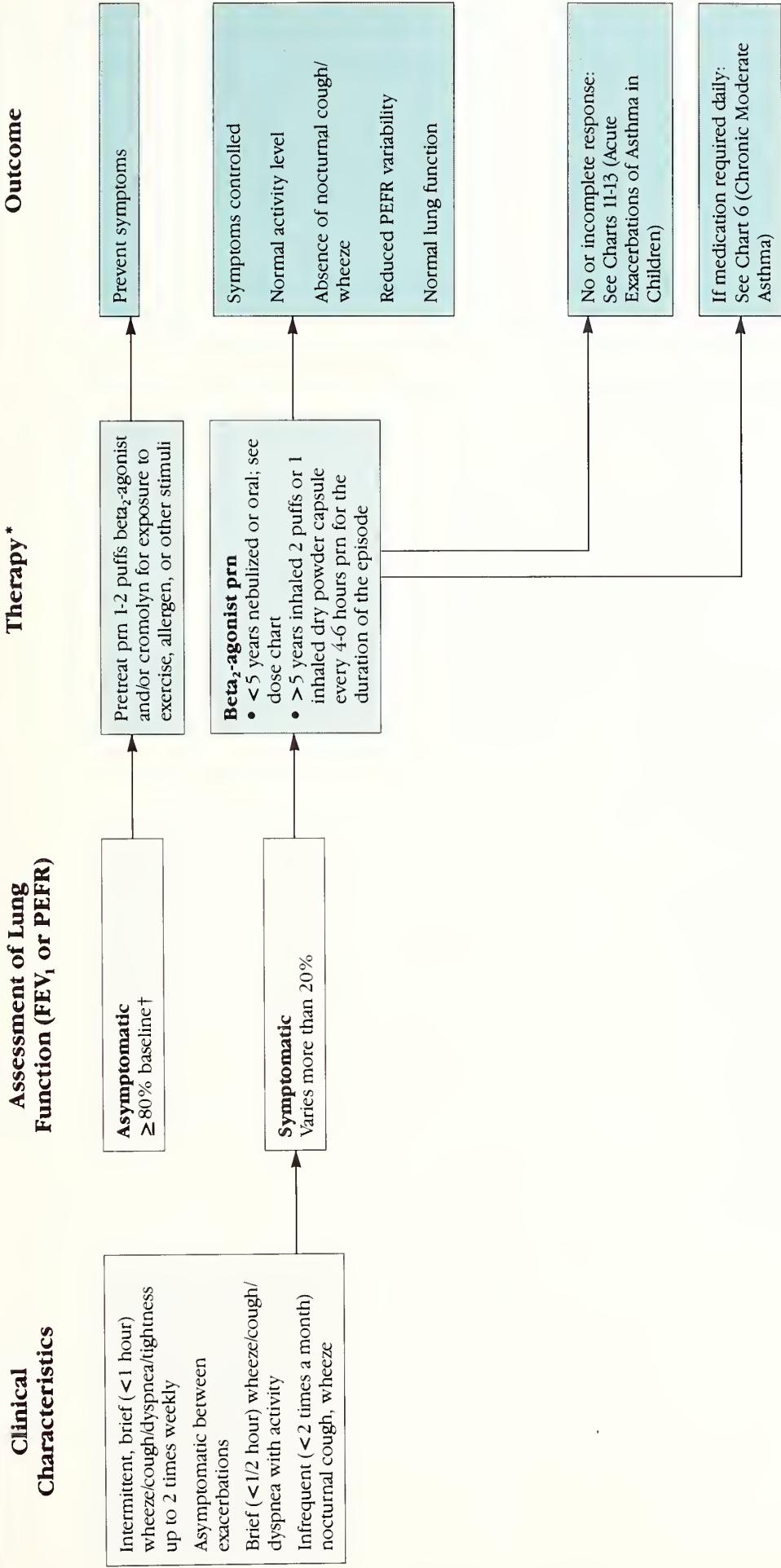
Mild Asthma (Chart 5)

The medication of choice for mild, intermittent asthma in children is inhaled beta₂-agonist taken on an as-needed (PRN) basis. How the therapy is administered depends largely on the patient's age: Most patients 5 years old and over are able to use a metered-dose inhaler; those under 5 usually can not. When a spacer device is used, MDIs can be used by children at an earlier age (3 to 5 years) as well as by older patients who have difficulty with the technique. (A spacer device provides a holding chamber for the medication and thus eliminates the problem of synchronizing actuation and inhalation.) A device that combines a face mask with a spacer may also allow MDIs to be used at an earlier age, although data evaluating this device are limited. Dry powder inhalers use an inhalation technique that requires less synchronization than MDIs and may also be considered.

For most children under 5, however, the choice is between oral and nebulized medication. Because nebulized beta₂-agonist medication is more effective and has fewer adverse effects (such as tremor and irritability), it is preferred for the child who has infrequent exacerbations but is nevertheless significantly compromised by them. Nebulizers are both expensive and difficult to transport (for example, to child care); thus children may take a combination of oral medications (away from home) and inhaled medications (at home).

Management of Asthma in Children

Chronic Mild Asthma



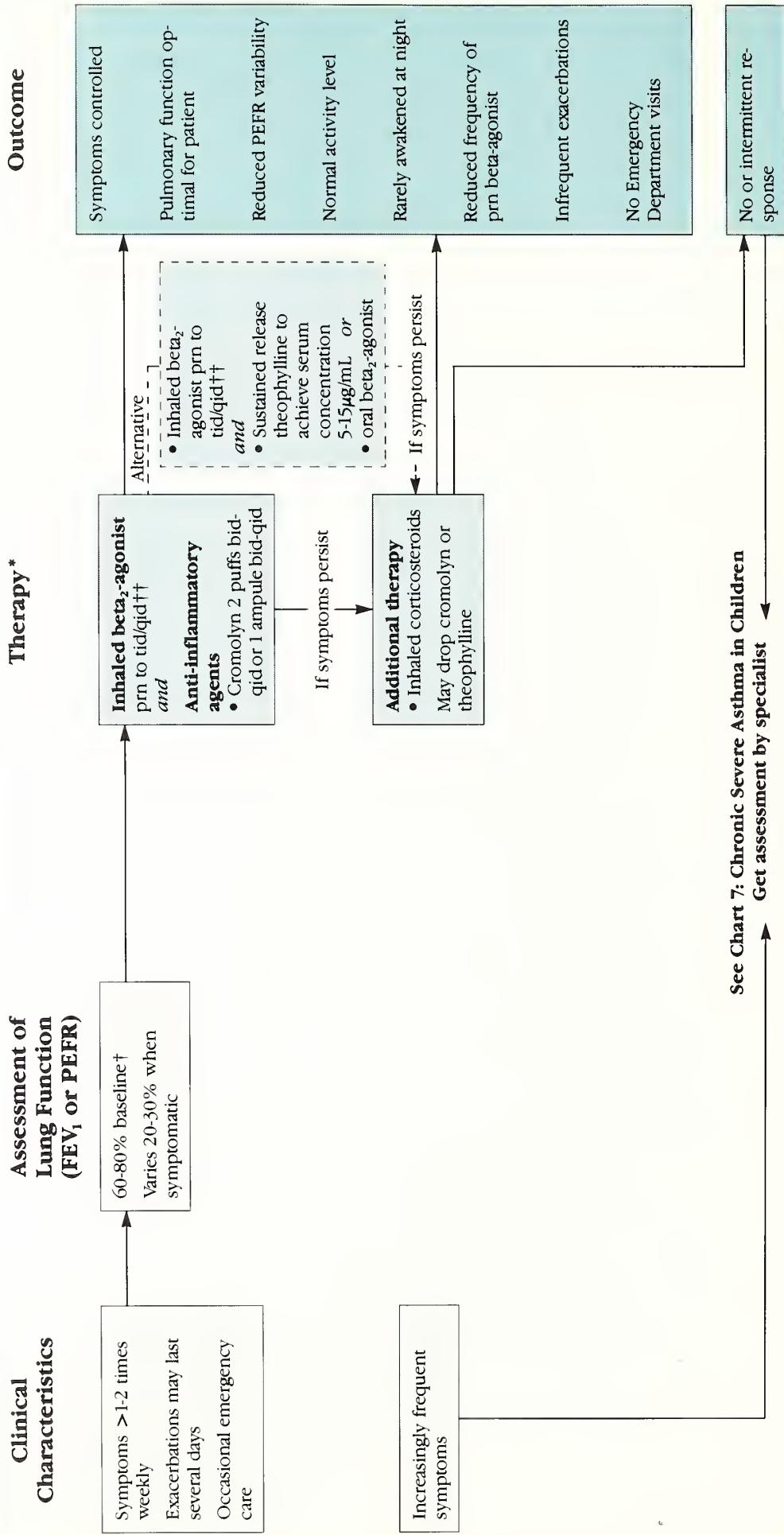
†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted of standardized norms or % patient's personal best.

*All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.

Chart 6

Management of Asthma in Children

Chronic Moderate Asthma



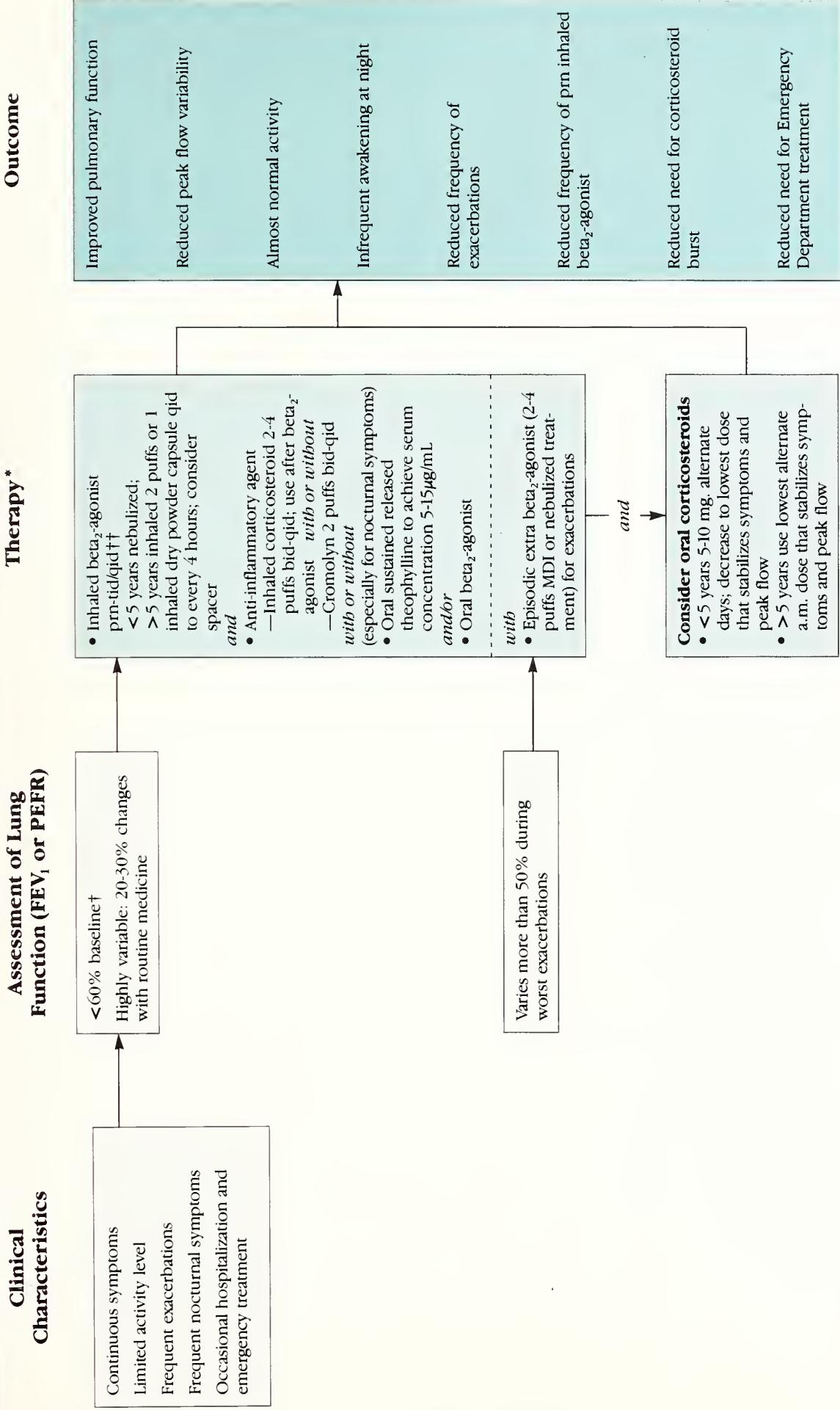
†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted based on standardized norms or % patient's personal best.

††If exceed 3-4 doses a day, consider additional therapy other than inhaled beta₂-agonist.

***All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.**

Management of Asthma in Children

Chronic Severe Asthma



Note: Individuals with severe asthma should be evaluated by an asthma specialist.

†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted of standardized norms or % patient's personal best.

††If exceed 3-4 doses a day, consider additional therapy other than inhaled beta₂-agonist.

***All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.**

Figure 4
Dosages for Therapy in Childhood Asthma

Beta₂-Agonists

Inhaled

Examples: Albuterol, metaproterenol, bitolterol, terbutaline, pirbuterol

Mode of administration

- Metered-dose inhaler 2 puffs q 4-6 hours
- Dry powder inhaler 1 capsule q 4-6 hours
- Nebulizer solution* Albuterol 5 mg/mL; 0.1-0.15 mg/kg in 2 cc of saline q 4-6 hours, maximum 5.0 mg
Metaproterenol 50 mg/mL; 0.25-0.50 mg/kg in 2 cc of saline q 4-6 hours, maximum 15.0 mg

Oral

Liquids	Albuterol	0.1-0.15 mg/kg q 4-6 hours
	Metaproterenol	0.3-0.5 mg/kg q 4-6 hours
Tablets	Albuterol	2 or 4 mg tablet, q 4-6 hours
		4 mg sustained-release tablet q 12 hours
	Metaproterenol	10 or 20 mg tablet q 4-6 hours
	Terbutaline	2.5 or 5.0 mg tablet q 4-6 hours

Cromolyn Sodium

MDI—1 mg/puff; 2 puffs bid-qid

Dry powder inhaler—20 mg/capsule; 1 capsule bid-qid

Nebulizer solution—20 mg/2 mL ampule; 1 ampule bid-qid

Theophylline

Liquid

Tablets, capsules

Sustained-release tablets, capsules

Dosage to achieve serum concentration of 5-15 µg/mL

Corticosteroids

*Inhaled***

Becломethасоне	42 µg/puff 2-4 puffs bid-qid
Тriамцинолон	100 µg/puff 2-4 puffs bid-qid
Флунисолид	250 µg/puff 2-4 puffs bid

*Oral****

Liquids	Prednisone	5 mg/5cc
	Prednisolone	5 mg/5cc
		15 mg/5cc
Tablets	Prednisone	1, 2.5, 5, 10, 20, 25, 50 mg
	Prednisolone	5 mg
	Methylprednisolone	2, 4, 8, 16, 24, 32 mg

*Premixed solutions are available. It is suggested that the per/kg dosage recommendations be followed.

**Consider use of spacer devices to minimize local adverse effects.

***For acute exacerbations, doses of 1-2 mg/kg in single or divided doses are used initially and are then modified. Reassess in 3 days, as only a short burst may be needed. There is no need to taper a short (3- to 5-day) course of therapy. If therapy extends beyond this period, it may be appropriate to taper the dosage.

For chronic dosage, the lowest possible alternate-day a.m. dosage should be established.

Moderate Asthma (Chart 6)

To avoid frequent fluctuations in PEFR and asthma symptoms as well as overuse of beta₂-agonist (exceeding three to four doses a day is not recommended), additional therapy is needed for children with moderate asthma. Beta₂-agonist is then used on an as-needed basis and serves as symptom reliever or rescue therapy. For preventive or maintenance therapy, there are three choices: cromolyn sodium, inhaled corticosteroid, or sustained-release theophylline.

Cromolyn sodium, an anti-inflammatory agent, can be used by most children over 5 years of age by MDI. Children under 5 and older children who can not master the use of an MDI with a spacer must use a nebulizer. Cromolyn sodium therapy may be initiated with a three- to four-times-a-day regimen; many patients can be successfully managed on a twice-a-day regimen.

Inhaled corticosteroid is an anti-inflammatory agent and an acceptable primary therapy for moderate asthma in children. However, a trial of cromolyn sodium should usually precede its use because of the extensive clinical experience with and study of cromolyn sodium. Inhaled corticosteroids are recommended for patients over 5 years of age who are taking cromolyn sodium but who continue to need a beta₂-agonist more than three to four times a day, or who continue to have nocturnal symptoms. After the patient stabilizes on the inhaled corticosteroid, usually after a 2- to 4-week period, the cromolyn sodium may be discontinued.

Sustained-release theophylline is an alternative primary therapy. Whether or not it provides anti-inflammatory activity is a subject of current debate. Theophylline is particularly helpful to patients with primarily nocturnal symptoms because a single evening dose may control those symptoms. Persistent nocturnal symptoms may, however, be an indication that more aggressive and anti-inflammatory medications are required. Sustained-release theophylline preparations are given in oral doses intended to achieve a serum

concentration of between 5 and 15 $\mu\text{g}/\text{mL}$. Theophylline may cause such side effects as irritability and gastrointestinal upset and must be monitored periodically to insure that the patient is within the proper therapeutic—but not toxic—range.

Severe Asthma (Chart 7)

For daily therapy, children with severe asthma require bronchodilators, including theophylline and a beta₂-agonist as needed to three or four times a day, in addition to anti-inflammatory agents. Children over 5 years of age should use an inhaled corticosteroid. Oral corticosteroids are used by younger children who usually are unable to use inhalers effectively. Oral corticosteroids should also be used by older children for whom questions of cost or compliance arise because they are less expensive and easier to use. Oral corticosteroids should be given as a single alternate-day, early-morning dose to minimize adverse effects.

Management of Exacerbations of Asthma

Exacerbations of asthma are acute or subacute episodes of progressively worsening shortness of breath, cough, wheezing, or chest tightness, or some combination of these symptoms. Respiratory distress is common. Exacerbations are characterized by decreases in expiratory airflow that can be documented and quantified by measurement of lung function (PEFR or spirometry).

General Considerations

■ Prevention and early treatment to reverse symptoms are the best strategies for management of asthma exacerbations. Important elements of this early treatment to prevent deterioration and abort the exacerbation include:

- Written action plans to help the patient to co-manage asthma exacerbations
- Recognition of early indicators of an exacerbation, including worsening PEFR or FEV₁

—Prompt communication between patient and health care provider about any serious deterioration and its treatment

—Appropriate intensification of anti-asthma medications, including in many cases a short course of systemic corticosteroids

—Removal of or withdrawal from any allergic or irritant trigger in the environment because treatment is less effective if there is continued exposure.

■ Patients at high risk of asthma-related death require special attention. This includes patients with a history of:

- Prior intubation for asthma
- Two or more hospitalizations for asthma in the past year
- Three or more emergency care visits for asthma in the past year
- Hospitalization or an emergency care visit for asthma within the past month
- Current use of systemic corticosteroids or recent withdrawal from systemic corticosteroids
- Past history of syncope or hypoxic seizure due to asthma
- Prior admission for asthma to a hospital-based intensive care unit
- Serious psychiatric disease or psychosocial problems.

Individuals with one or more of these risk factors require particularly intensive patient education, close monitoring, and prompt care. They should be counseled to seek medical care early during an exacerbation and instructed about the availability and appropriate use of ambulance services.

Treatment Goals

The principal goals of treatment in exacerbations of asthma are:

■ Rapid reversal of airflow obstruction, thereby relieving respiratory distress.

—Repetitive administration of inhaled beta₂-agonists best achieves this rapid reversal of airflow obstruction.^{1,2}

—Early addition of systemic corticosteroids speeds the rate of improvement among patients who fail to respond or respond incompletely to inhaled beta₂-agonists.³

■ Correction of significant hypoxemia

hypoxemia, if present, by administering supplemental oxygen. In rare instances, severe alveolar hypoventilation requires mechanically assisted ventilation.

■ Reduction of the rate of recurrent severe asthma symptoms

by intensifying the patient's antiasthma medication regimen upon discharge from the emergency department. Often a short course of oral corticosteroids is useful.

Crucial to successful achievement of these treatment goals is close monitoring of the patient's condition and response to treatment with serial measurements of lung function. These measurements provide quantification of the severity of the asthma exacerbation and of the extent of improvement with treatment. The ranges for PEFR and FEV₁ in the protocols are general guidelines, not precise criteria. PEFR and FEV₁ results should be seen as aids in a monitoring and decision-making process that also takes into account such other factors as the patient's history, current symptoms, and physical findings.

Protocols for Management of Exacerbations of Asthma

This section and its accompanying charts present in general terms methods for managing asthma exacerbations in home, emergency department, and hospital settings. Specific discussion of important considerations at each of the steps illustrated in the charts is included in the full report, *Guidelines for the Diagnosis and Management of Asthma*, but is beyond the scope of this summary.

Home Management of Exacerbations of Asthma in Adults (Chart 8) and Children (Chart 11)

Important to the successful management of exacerbations of asthma is early initiation of antiasthma therapy. When patients are able to begin treatment at home, they not only avoid delays in treatment but also add to their sense of control over their lives and their asthma. The degree of care provided in the home depends on the physician's and the patient's (or parents') experience and the availability of emergency care. (For example, patients who live in rural settings may, by necessity, have to manage asthma exacerbations at home.) Many patients who have moderately severe to severe asthma will have the equipment (compressor-driven nebulizer for young children) and medications at home necessary for treating and monitoring an asthma exacerbation. For school-age children, a management plan for exacerbations occurring at school can be adapted from the home management plan.

For any individual patient, the optimal management strategy may evolve out of patient and physician experience with what "works" and what does not in treating acute exacerbations. General guidelines applicable to most patients are presented in Charts 8 and 11.

■ Home PEFR determinations are an integral part of home management strategies. They make it possible for the patient to obtain information, which can then be shared with the clinician, regarding the severity of the exacerbation and the response to treatment.

■ Patients are encouraged to use inhaled beta₂-agonist medications with increased frequency during an exacerbation and, under certain circumstances, begin or increase the dose of systemic corticosteroids.

■ Patients should not delay in seeking professional medical help if the asthma exacerbation is severe, if therapy does not give rapid improvement, if sustained improvement is not achieved, or if there

is further deterioration. (For assessment criteria, see Figures 5, 6, and 7, pages 23 and 25.)

■ Recovery from an acute exacerbation is often gradual. Medications for acute therapy may need to be continued for several days to sustain relief of symptoms and improvement in PEFR. However, patients should seek medical care rather than rely on bronchodilator therapy in excessive doses or for prolonged periods of time.

■ NOT recommended are the following home management techniques:

- Drinking large volumes of liquids or breathing warm, moist air (e.g., the mist from a hot shower)
- Rebreathing into a bag held tightly at the nose and mouth
- Using over-the-counter antihistamines and cold remedies.

■ Pursed-lips breathing and other forms of controlled breathing may help to maintain calm during a period of respiratory distress, but they do not bring about any improvement in lung function.

Hospital-Based Emergency Department Management and Hospital Management of Exacerbations of Asthma in Adults (Charts 9 and 10) and Children (Charts 12 and 13)

Severe exacerbations of asthma are potentially life threatening. Care must be expeditious.

Effective therapies may be available in a physician's office. However, serious exacerbations require close observation, frequent treatment, and repetitive measurements of lung function. Most severe exacerbations of asthma in both adults and children require prompt transfer to and a complete course of therapy in an emergency department or hospital.⁴ Overviews of these treatment strategies are presented for adults in Charts 9 and 10 and for children in Charts 12 and 13.

Assessment. In the emergency department, a brief history and physical examination pertinent to the exacerbation are appropriate prior to treatment. A more detailed history and complete physical examination should be performed once therapy has been started.

■ Important questions to ask in obtaining a **brief history** concern:

- Time of onset and cause of present exacerbation of asthma
- Severity of symptoms, including exercise limitation and sleep disturbance
- All current medications
- Prior hospitalizations and emergency department visits for asthma, particularly within the past year
- Prior episodes of respiratory insufficiency due to asthma (loss of consciousness or intubation and mechanical ventilation)
- Significant prior cardiopulmonary disease.

■ Objectives of the **physical examination** include:

- Assessment of the severity of the exacerbation (see Figure 5 for indices of severe asthma exacerbations). Predictors of severe airflow obstruction include pulsus paradoxus (greater than or equal to 12 mm Hg fall in systolic blood pressure during inspiration), use of accessory muscles of respiration, and diaphoresis and inability to recline with head elevated less than 30°.
- Identification of complications (e.g., pneumonia, atelectasis, pneumothorax, or pneumomediastinum).
- Assessment of overall patient status, including level of alertness, fluid status, and presence of cyanosis, respiratory distress, and wheezing. (Wheezing can be an unreliable indicator of obstruction; in rare cases, extremely severe obstruction may be accompanied by a “silent chest.”⁵)

Figure 5

Emergency Department Indices of Acutely Severe Asthma in Adults

Symptoms/Historical Data

- Severe breathlessness, cough, chest tightness, and wheezing
- Difficulty walking 100 feet or more
- Speech fragmented by rapid breathing
- Syncope or near syncope

Physical Findings

- Paradoxical pulse (≥ 12 mm Hg)
- Use of accessory muscles of respiration
- Diaphoresis; inability to lie supine
- Heart rate >120 beats/min
- Respiratory rate >30 breaths/min

Expiratory Flow

- FEV₁ or PEFR $<30-50\%$ baseline (predicted or personal best, as determined by the clinician)
- Failure of PEFR to improve at least 10% after initial treatment

Oxygenation

- PO₂ <60 mm Hg or
- O₂ saturation $<90\%$

Ventilation

- PCO₂ ≥ 40 mm Hg

Functional assessments

In the emergency department assessment of PEFR or FEV₁ at least hourly. *In the hospital*, measurements should be made before and after bronchodilator therapy at least twice daily.

In both the emergency department and hospital measurements should be made of arterial oxygen saturation by pulse oximetry (where available).

Laboratory studies

In the emergency department such laboratory studies as complete blood count (CBC), chest x-ray, and serum theophylline concentration are rarely needed for initial assessment and their performance should not be permitted to delay initiation of treatment.

After initial treatment in the emergency department:

- CBC is appropriate in patients with fever or purulent sputum.
- Chest x-ray should be obtained in patients suspected of a complicating cardiopulmonary process and all patients admitted to the hospital for an asthma exacerbation.
- Serum theophylline concentration should be measured in patients taking theophylline prior to presentation.

Arterial blood gas (ABG) measurements should be performed to evaluate arterial carbon dioxide tension (PCO₂) in patients with obvious hypoventilation, cyanosis, or severe distress after initial treatment, especially if PEFR or FEV₁ is less than or equal to 25 percent of predicted. Patients with arterial PCO₂ greater than or equal to 40 mm Hg will require repeated ABG measurements to monitor their response to treatment.

Characteristics identifying patients at particular risk for life-threatening deterioration

include:

- Infants less than 1 year old
- Prior history of life-threatening exacerbations
- Less than 10 percent improvement in PEFR or FEV₁ in the emergency department
- PEFR or FEV₁ less than 25 percent of predicted
- PCO₂ greater than or equal to 40 mm Hg
- Wide daily fluctuations in PEFR or FEV₁.

■ Assessment considerations unique to children and infants.

—It is often difficult for the physician and parent to determine the severity of the airway obstruction in the infant and small child with asthma. However, by using a combination of the subjective and objective parameters in Figure 6, a fairly accurate assessment can be made and treatment instituted promptly. Many of these parameters have not been quantitated or systematically studied, so they serve only as a general guide.

—In infants, several differences in lung anatomy and physiology place them at greater risk than older children for respiratory failure. These differences include increased peripheral airway resistance, deficient collateral channels of ventilation, airway smooth muscle that extends in a spiral manner further into the peripheral airways, decreased elastic recoil pressure, and mechanically disadvantaged diaphragm. Viral infections, particularly respiratory syncytial virus, are the most common etiology of acute asthma in children under 6 months. The pathology is frequently in the small airways or bronchioles leading to edema, air trapping and hyperinflation, atelectasis, increased respiratory rate, and wheezing. This sequence of changes can rapidly progress to respiratory failure. Close monitoring is critical.

—Because of their ventilation/perfusion abnormalities, infants become hypoxic earlier than adults. Thus oxygen saturation measurements should be performed on all infants by pulse oximetry and should be greater than 93 percent. Decreased oxygen saturation is often an early sign of moderate-to-severe airway obstruction. In addition, a measurement of less than 91 percent in room air is a good

predictor in small infants of the need for hospitalization.

—Arterial or capillary blood gas measurements should be performed in all infants with oxygen saturation less than 90 percent. The PCO_2 is the best measurement of ventilation in an infant.

Treatment. In the emergency department and hospital, the primary therapies are repeated administration of inhaled β_2 -agonist bronchodilators and systemic corticosteroids. Supplemental oxygen should be given to patients with significant hypoxemia and to all patients when arterial oxygen monitoring is not available. Other treatment may include methylxanthines and antibiotics.

■ **Beta₂-agonists** (for recommended doses, see Figure 8 for adults and Figure 9 for children).

—Reversal of airflow obstruction is most effectively achieved by the repetitive administration of inhaled β_2 -agonist bronchodilators.

—Inhalation of a β_2 -agonist solution aerosolized by nebulizer is favored for both children and adults, although some studies raise the possibility that supervised delivery by MDI with a spacer device may be equally effective.

—Onset of action for inhaled β_2 -agonist is less than 5 minutes; repetitive administration produces incremental bronchodilation.

—Duration of action in severe asthma is not precisely known.

—**For adults in the emergency department**, three doses spaced every 20 to 30 minutes can safely be given as initial therapy to patients without comorbid cardiovascular disease. Thereafter, the frequency of administration varies according to severity of patients' symptoms and occurrence of adverse medication side effects. In patients without underlying cardiovascular disease, administration as frequently as every 1 to 2

hours is safe for periods of severe airflow obstruction.

—**For children in the emergency department**, albuterol is specifically recommended because its safety in frequently administered high doses has been established.⁶⁴ Albuterol can be delivered by nebulizer, preferably with oxygen. Nebulized treatments should be given every 20 minutes for 1 hour, and the patient should be continually assessed.

—**For children in the hospital**, albuterol may be given hourly and the frequency increased until it is given continuously.

■ **Systemic corticosteroids** (for recommended doses, see Figure 8 for adults and Figure 9 for children).

—**In the emergency department:** Immediate administration of systemic corticosteroids may be warranted in some patients with very severe exacerbations of asthma in whom no improvement is observed after the initial dose of β_2 -agonist, or in those patients who developed an exacerbation despite the regular use of oral corticosteroids.^{1,15-17} Patients with severe airflow obstruction (PEFR or FEV_1 less than or equal to 40 percent of predicted or of the best value at baseline) after the initial hour of treatment should be given systemic corticosteroids.

—**In the hospital:** Systemic corticosteroids speed the resolution of severe asthma exacerbations refractory to bronchodilator therapy and should be given to all children and adults admitted to the hospital for severe asthma.

—**In infants and children**, corticosteroids are particularly important. These agents should be given very early in the course of a severe asthma exacerbation and should be started if the infant or child fails to respond completely to two albuterol treatments.

Figure 6

Estimation of Severity of Acute Exacerbations of Asthma in Children

Sign/Symptom	Mild	Moderate	Severe
PEFR*	70-90% predicted or personal best	50-70% predicted or personal best	<50% predicted or personal best
Respiratory rate, resting or sleeping (see Fig. 7)	Normal to 30% increase above the mean	30-50% increase above the mean	Increase over 50% above the mean
Alertness	Normal	Normal	May be decreased
Dyspnea**	Absent or mild; speaks in complete sentences	Moderate; speaks in phrases or partial sentences; infant's cry softer and shorter, infant has difficulty sucking and feeding	Severe; speaks only in single words or short phrases; infant's cry softer and shorter, infant stops sucking and feeding
Pulsus paradoxus***	<10 mm Hg	10-20 mm Hg	20-40 mm Hg
Accessory muscle use	No intercostal to mild retractions.	Moderate intercostal retraction with tracheosternal retractions; use of sternocleidomastoid muscles; chest hyperinflation	Severe intercostal retractions, tracheosternal retractions with nasal flaring during inspiration; chest hyperinflation
Color	Good	Pale	Possibly cyanotic
Auscultation	End expiratory wheeze only	Wheeze during entire expiration and inspiration	Breath sounds becoming inaudible
Oxygen saturation	>95%	90-95%	<90%
PCO ₂	<35	<40	>40

Note: Within each category, the presence of several parameters, but not necessarily all, indicate the general classification of the exacerbation.

*For children 5 years of age or older.

**Parents' or physicians' impression of degree of child's breathlessness.

***Pulsus paradoxus does not correlate with phase of respiration in small children.

Figure 7

Respiratory Rates (Breaths/Minute) of Normal Children, Sleeping and Awake

Age	Sleeping			Awake			Mean Difference Between Sleeping and Awake
	No.	Mean	Range	No.	Mean	Range	
6-12 months	6	27	22-31	3	64	58-75	37
1-2 years	6	19	17-23	4	35	30-40	16
2-4 years	16	19	16-25	15	31	23-42	12
4-6 years	23	18	14-23	22	26	19-36	8
6-8 years	27	17	13-23	28	23	15-30	6

Source: Waring WW. The history and physical exam, in Kendig, Cherniak (eds.): *Disorders of the Respiratory Tract in Children*. Philadelphia, W.B. Saunders, 1983, p. 63.

Oxygen. Supplemental oxygen should be administered (by nasal cannulae or, in children, by mask) to the hypoxemic patient to achieve an arterial oxygen saturation of greater than or equal to 90 percent. Because arterial oxygen saturation may intermittently decline during the course

of the acute exacerbation and in response to bronchodilator treatment, the criteria for oxygen supplementation should be more liberal (e.g., arterial oxygen saturation of less than or equal to 92 percent) among patients at risk for adverse consequences of transient hypox-

emia (such as children and infants and patients who are pregnant, elderly, or have known coronary artery disease).

In the absence of available continuous oxygen monitoring, supplemental oxygen should be administered to all patients.

■ **Methylxanthines** (see Figures 8 and 9 for recommended doses).

—*In the emergency department:*

Intravenous aminophylline is not recommended. It has been demonstrated that in the first 4 hours of treatment aminophylline provides no additional benefit to optimal inhaled beta₂-agonist therapy.^{7,18} When used in combination with repetitively administered beta₂-agonist bronchodilators, intravenous aminophylline causes increased adverse side effects without affecting additive bronchodilation.¹⁹⁻²¹

—In patients currently taking a theophylline-containing preparation, serum theophylline concentration should be determined if a recent theophylline level is not available.

—*In the hospital:* Therapy with oral or intravenous methylxanthines is recommended for adults and children hospitalized with severe asthma.²²⁻²⁴ The precise benefit that they afford remains to be defined; but it may be that as the frequency of administration of inhaled beta₂-agonists is reduced (e.g., overnight or secondary to adverse side effects), methylxanthines prolong or sustain the bronchodilator response between doses.

—Oral theophylline and intravenous aminophylline are equally effective when the serum theophylline concentrations achieved by the two routes of administration are identical. Patients who take theophylline as part of their maintenance therapy for asthma and who are not vomiting can be maintained on oral therapy with a sustained-release preparation. The dose should be adjusted according to the serum concentration of theophylline.

—*For infants* in their first 6 months, metabolism of theophylline is considerably reduced, although it increases later in childhood. Doses should be adjusted appropriately.

■ **Antibiotics.** Bacterial and mycoplasmal respiratory tract infections are thought to contribute only infrequently to severe exacerbations of asthma. The use of antibiotics is generally reserved for those patients with purulent sputum (discolored because of polymorphonuclear leukocytes, not eosinophils), especially when combined with fever. The presence of bacterial sinusitis should be considered and treated with antibiotics if suspected.

Some treatments—anticholinergics, hydration, and chest physical therapy—are generally not beneficial; others—mucolytics and sedation—should be avoided.

■ **Anticholinergics.** Ipratropium bromide in metered-dose inhaler form does not appear to benefit patients receiving intensive bronchodilator therapy with beta₂-agonists. In contrast, ipratropium bromide nebulizer solution may be of some benefit for hospitalized patients, but it is not currently available in the United States.

■ **Hydration.** Among older children and adults intravenous or oral administration of large volumes of fluids does NOT play a role in the management of severe asthma. However, infants and young children may become dehydrated as a result of increased respiratory rates and decreased oral intakes. In these latter age groups, assessment of fluid status should be made (urine output, urine specific gravity, mucous membrane moisture, electrolytes) and appropriate corrections provided.

■ **Chest physical therapy.** In general, among patients with normal respiratory muscle strength and effective cough, chest physical therapy is not beneficial and may be unnecessarily stressful for the severely breathless patient. However, in selected adults and children who manifest severe mucus hypersecretion or atelectasis as part of their asthma exacerbation, postural drainage, chest vibration and percussion, and other techniques of chest physical therapy may be beneficial.

■ **Mucolytics.** Administration of mucolytic agents (e.g., acetylcysteine, potassium iodide) in severe exacerbations of asthma may worsen cough or airflow obstruction and should be *avoided*.

■ **Sedation.** Because of their respiratory depressant effect, anxiolytic and hypnotic drugs should be *strictly avoided* in severely ill adult and child asthma patients.

With intensive therapy, unpleasant side effects (e.g., palpitations, tremulousness, sense of inner raciness, headache) are common, but injurious adverse reactions (e.g., significant cardiac arrhythmias or myocardial ischemia) are rare.

Treatment of impending respiratory failure (patients with severe asthma and an arterial PCO₂ greater than or equal to 40 mm Hg after intensive therapy) should be treated in an intensive care unit. In general, if there is steady deterioration in clinical signs and symptoms despite intensive therapy for asthma, the patient should be intubated and mechanically ventilated when the PCO₂ is greater than or equal to 50 mm Hg and rising.

For children in the intensive care unit: If after treatments with albuterol, oxygen, corticosteroids, and aminophylline the patient does not improve (PEFR less than 25 percent, PCO₂ greater than 45 mm Hg), and other parameters are worsening, intravenous terbutaline²⁵⁻³⁰ may be added with close monitoring. Intravenous isoproterenol is not recommended because its beta₁ effect causes significant tachycardia and toxicity.³¹ (Intravenous terbutaline is not recommended for adults.) An arterial line should be placed for continuous blood pressure, heart rate, and blood gas monitoring. If a trial of intravenous terbutaline does not result in an improvement and the patient is having progressive increases in fatigue, the patient should be mechanically ventilated while continued on all medications.^{32,33} Ventilation of an asthma patient is difficult and always requires the assistance of a qualified specialist.

Figure 8

Dosages of Drugs in Acute Exacerbations of Asthma in Adults

Inhaled Beta-Agonists

- Albuterol 2.5 mg (0.5 cc of a 0.5% solution, diluted with 2-3 cc of normal saline); or
- Metaproterenol 15 mg (0.3 cc of a 5% solution, diluted with 2-3 cc of normal saline); or
- Isoetharine 5 mg (0.5 cc of a 1% solution, diluted with 2-3 cc of normal saline); or

Subcutaneous Beta-Agonists

- Epinephrine 0.3 mg s.q.; or
- Terbutaline 0.25 mg s.q.

Methylxanthines

■ Intravenous

—Aminophylline 0.6 mg/kg/hr by continuous infusion. Lean body weight should be used for these calculations in obese patients. In patients not previously receiving a methylxanthine, a loading dose (6 mg/kg) should be administered. The continuous infusion rate should be adjusted for factors that alter the metabolism of theophylline, including liver disease, congestive heart failure, cigarette smoking, and certain medications (e.g., erythromycin, cimetidine, and ciprofloxacin). The continuous infusion rate should be adjusted according to the serum theophylline level, which should be measured first approximately 6 hours after infusion begins.

■ Oral

—Daily theophylline dose (mg) = total dose (mg) of aminophylline per 24 hours $\times .80$.
—The dose of theophylline can be given as a sustained-release preparation in two divided doses or a once-daily preparation.

Corticosteroids

■ Intravenous

—Methylprednisolone 60-80 mg i.v. bolus every 6-8 hours; or
—Hydrocortisone 2.0 mg/kg i.v. bolus every 4 hours; or
—Hydrocortisone 2.0 mg/kg i.v. bolus, then 0.5 mg/kg/hr continuous intravenous infusion.

■ Oral

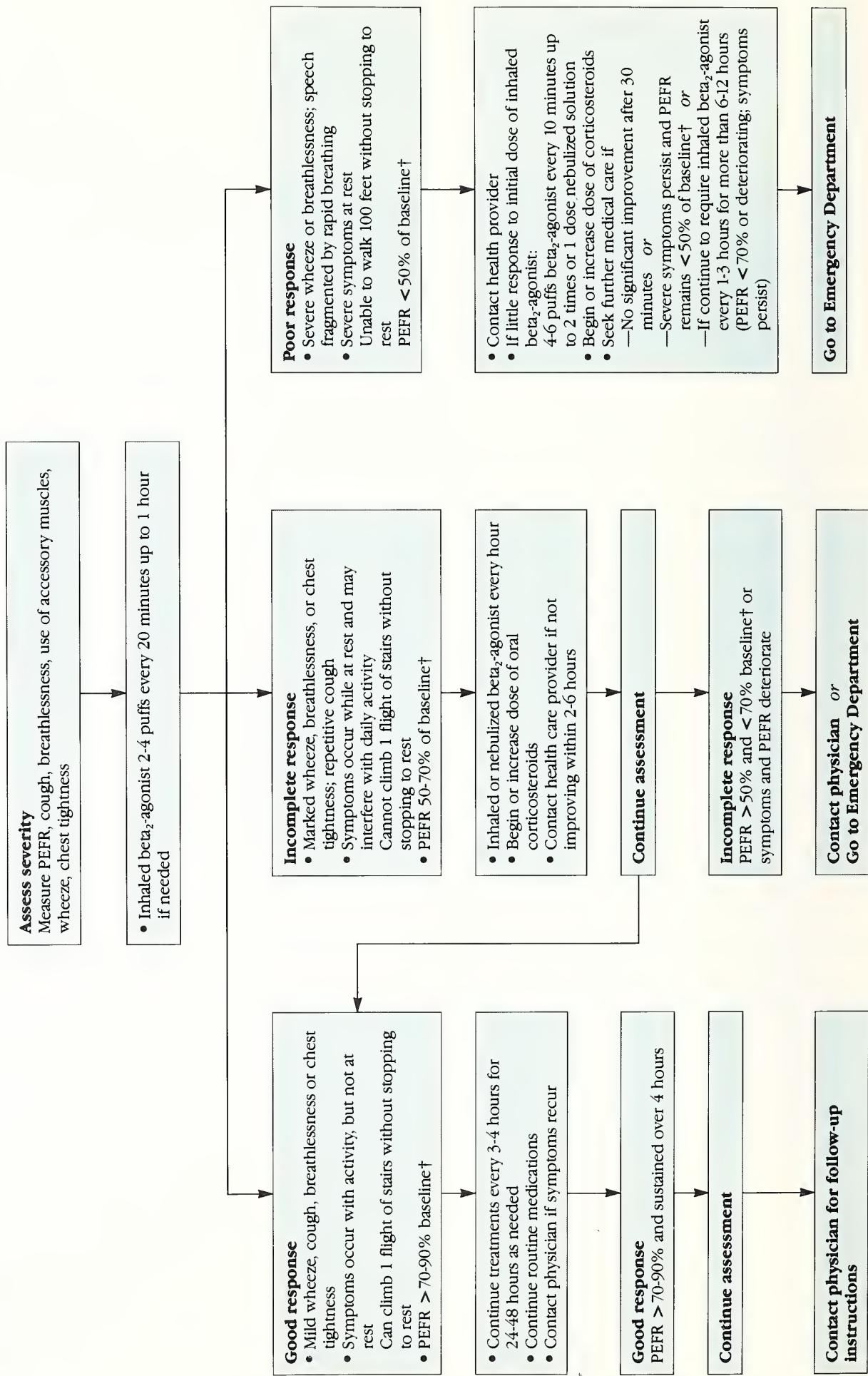
—A typical oral regimen that may be used as a substitute for intravenous corticosteroids might be prednisone or methylprednisolone 60 mg given immediately, then 60-120 mg per day in divided doses, tapered over several days at the discretion of the physician.

With improvement in the patient's condition, corticosteroids are usually tapered to a single daily dose of oral prednisone or methylprednisolone (e.g., 60 mg/day), or divided doses (e.g., 20 mg tid), then gradually further reduced over several days.

If the patient requires a prolonged course of oral corticosteroids, side effects may be minimized by a single a.m. dose given on alternate days.

Acute Exacerbations of Asthma in Adults

Home Management



†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted based on standardized norms or % patient's personal best.

Acute Exacerbations of Asthma in Adults*

Emergency Department Management

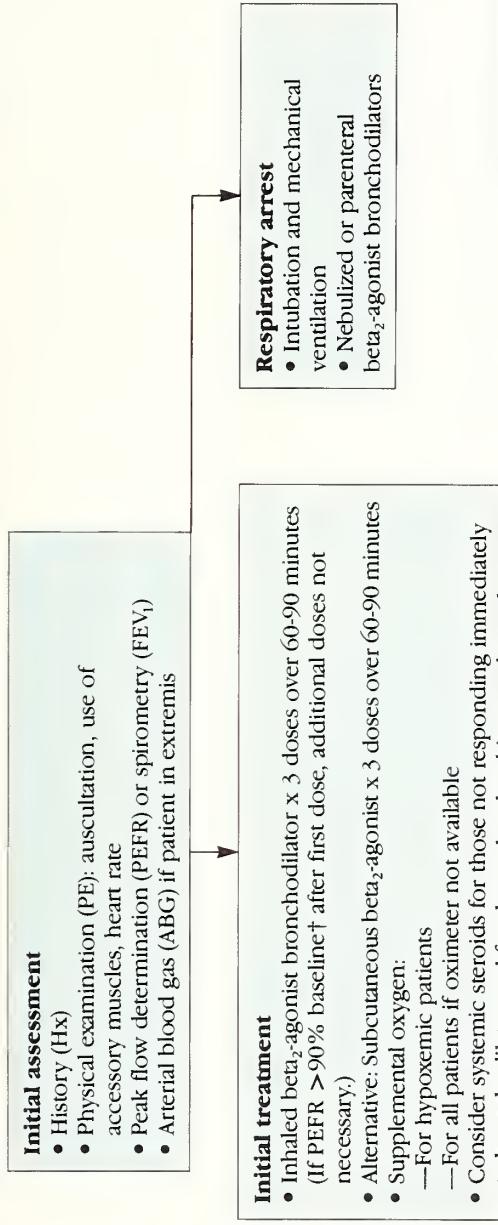


Chart 8

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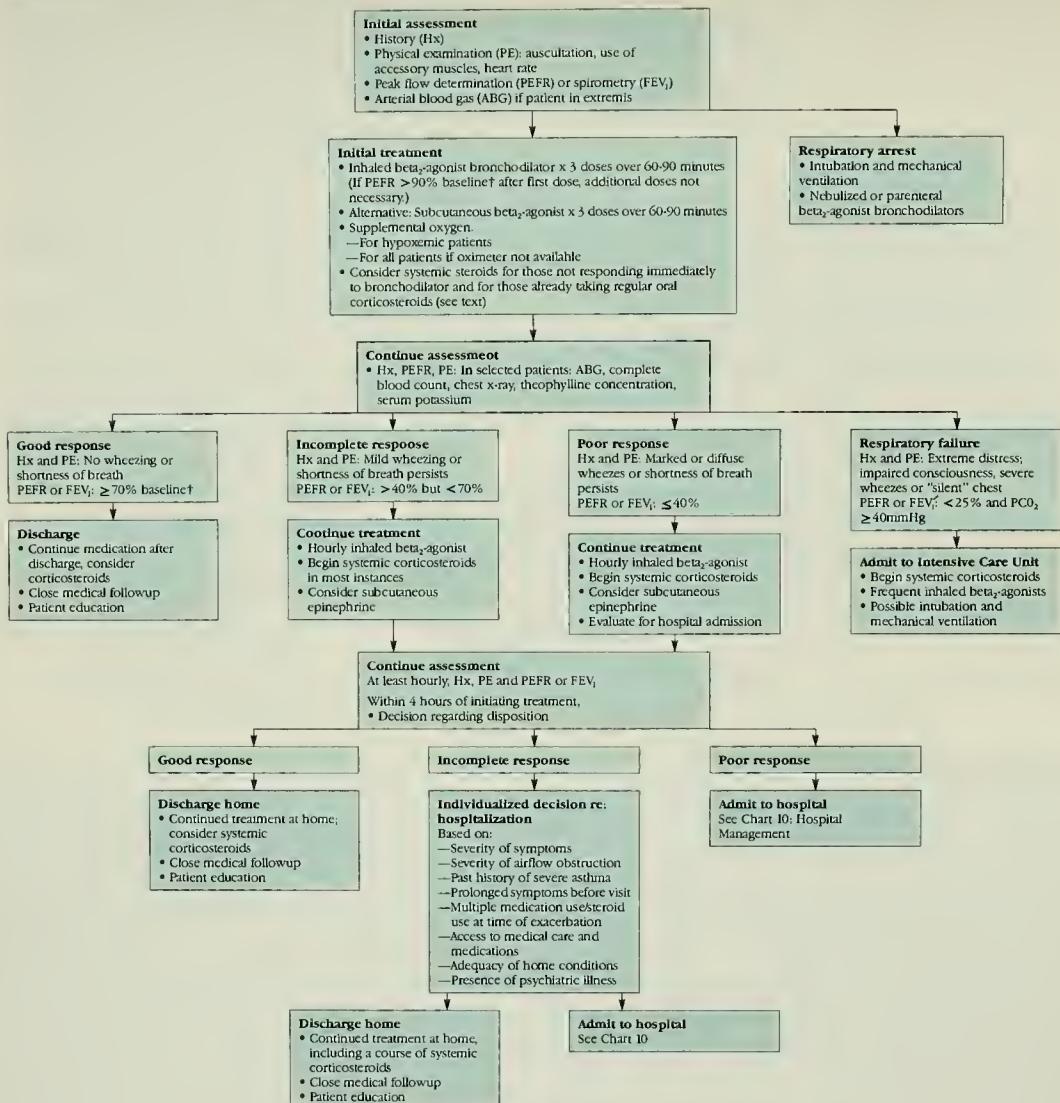
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Chart 9

Acute Exacerbations of Asthma in Adults*

Emergency Department Management

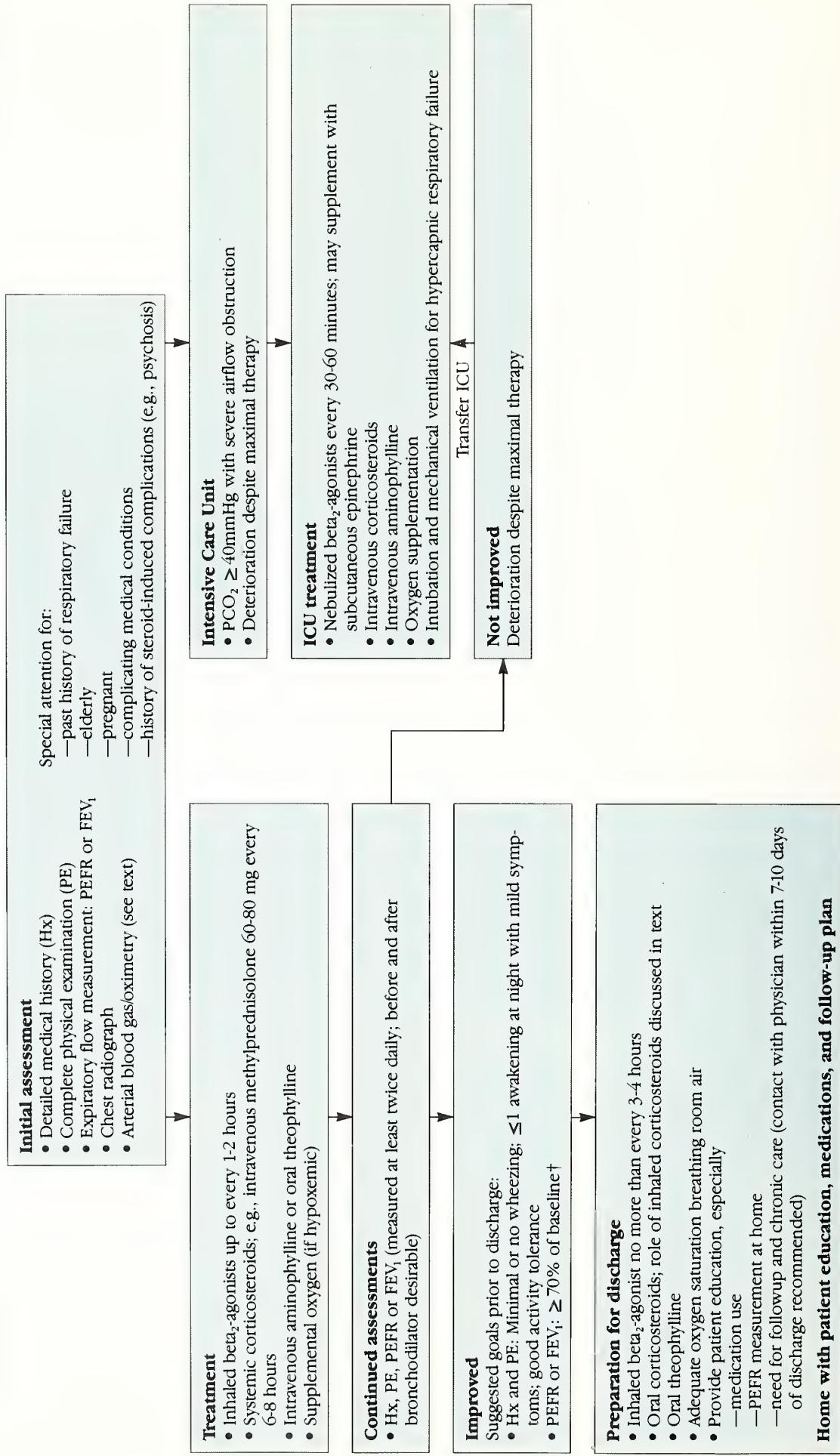


*Therapies are often available in a physician's office. However, most acutely severe exacerbations of asthma require a complete course of therapy in an Emergency Department

†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % of standardized norms or % patient's personal best

Acute Exacerbations of Asthma in Adults

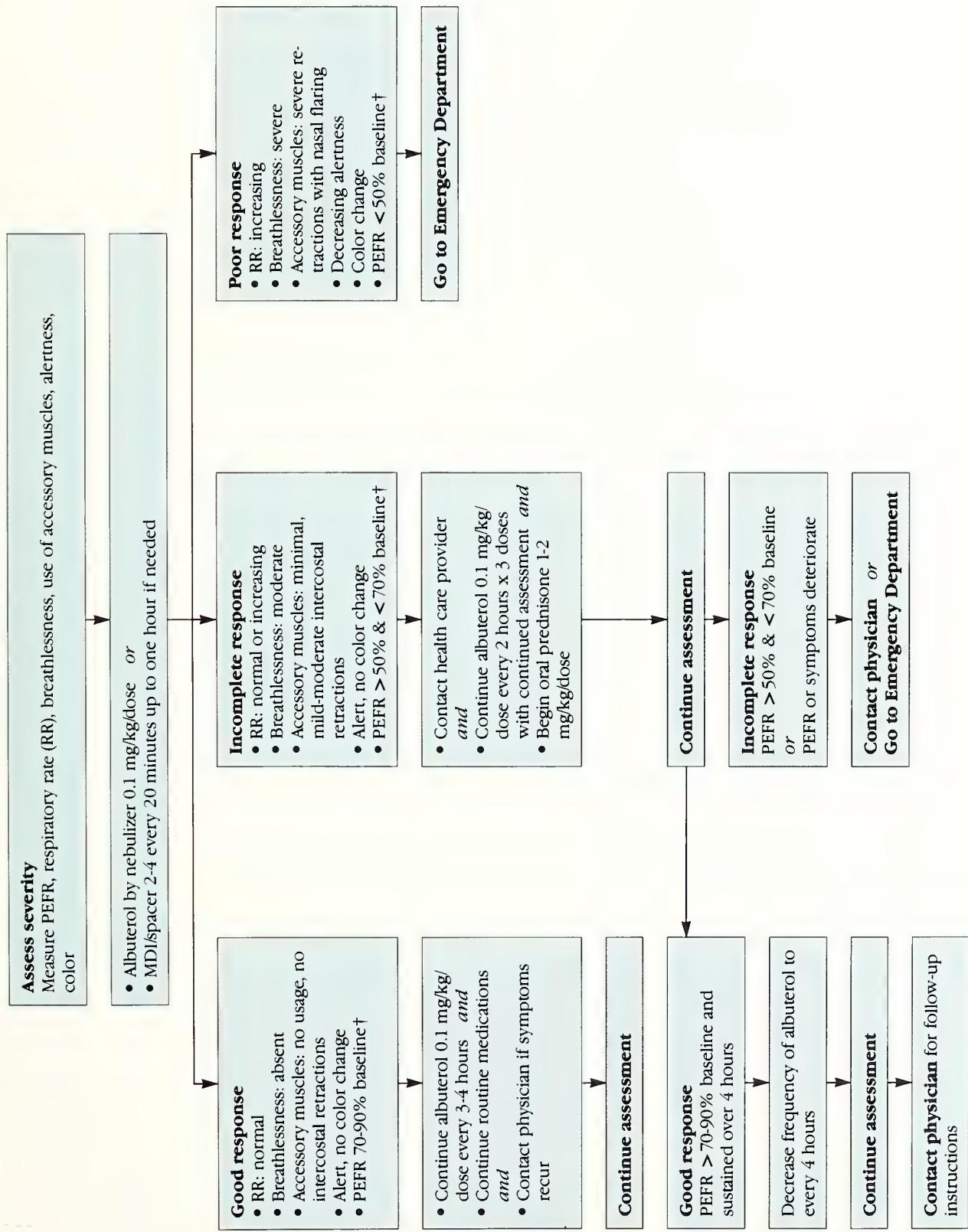
Hospital Management



†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted based on standardized norms or % patient's personal best.

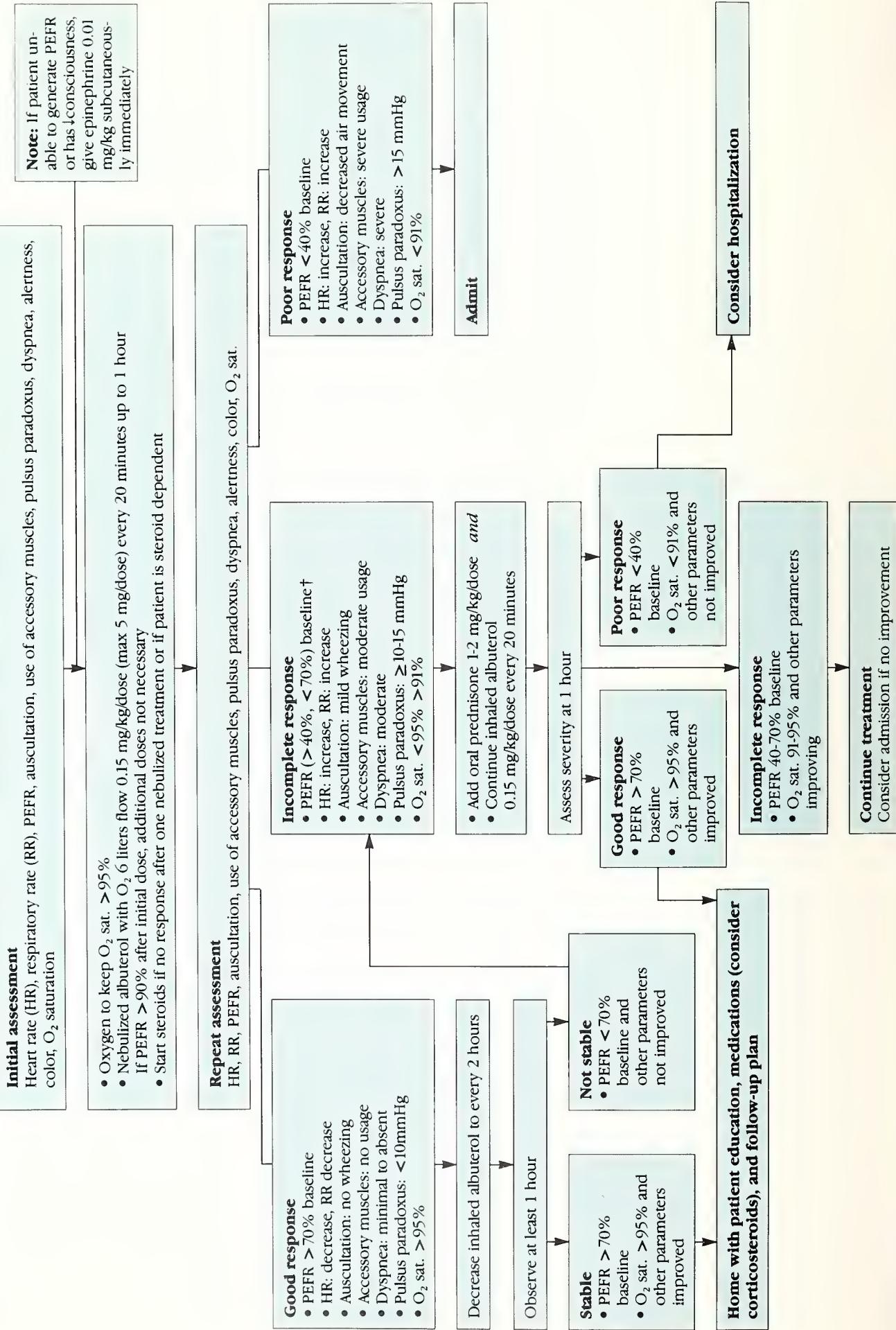
Acute Exacerbations of Asthma in Children

Home Management



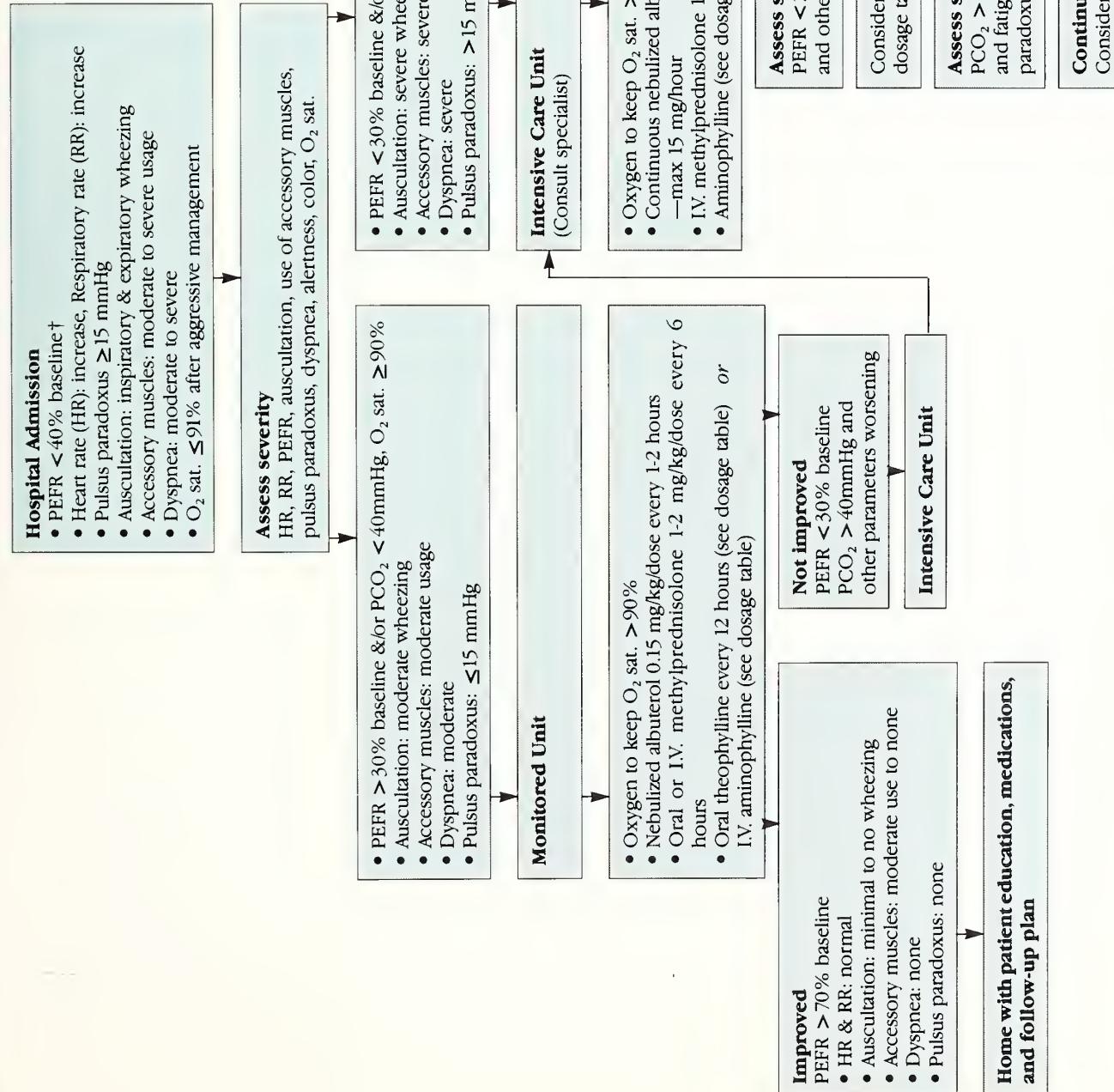
Acute Exacerbations of Asthma in Children

Emergency Department Management*



Acute Exacerbations of Asthma in Children

Hospital Management



†PEFR % baseline refers to the norm for the individual, established by the clinician. This may be % predicted based on standardized norms or % patient's personal best.

Figure 9

Dosages of Drugs in Acute Exacerbations of Asthma in Children

Drug	Available Form	Dosage	Comment
Inhaled Beta₂-Agonist			
<i>Albuterol</i>			
Metered-dose inhaler	90 µg/puff	2 inhalations every 5 min for total of 12 puffs, with monitoring of PEFR or FEV ₁ to document response	If not improved, switch to nebulizer. If improved, decrease to 4 puffs every hour.
Nebulizer solution	0.5% (5 mg/mL)	0.1-0.15 mg/kg/dose up to 5 mg every 20 min for 1-2 hrs (minimum dose 1.25 mg/dose) ¹⁹ 0.5 mg/kg/hr by continuous nebulization ¹⁴ (maximum 15 mg/hour)	If improved, decrease to 1-2 hours. If not improved, use by continuous inhalation.
<i>Metaproterenol</i>			
Metered-dose inhaler	650 µg/puff	2 inhalations	Frequent high-dose administration has not been evaluated. Metaproterenol is not interchangeable with beta ₂ -agonists albuterol and terbutaline.
Nebulizer solution	5% (50 mg/mL)	0.1-0.3 cc (5-15 mg). Do not exceed 15 mg.	
	0.6% unit dose vial of 2.5 mL (15 mg)	As above 5-15 mg. Do not exceed 15 mg.	
<i>Terbutaline</i>			
Metered-dose inhaler	200 µg/puff	2 inhalations every 5 min for a total of 12 puffs	
Injectable solution used in nebulizer	0.1% (1 mg/1 mL) solution in 0.9% NaCl solution for injection Not FDA approved for inhalation.		Not recommended as not available as nebulizer solution. Offers no advantage over albuterol, which is available as nebulizer solution.
Systemic Beta-Agonist			
<i>Epinephrine HCl</i>	1:1000 (1 mg/mL)	0.01 mg/kg up to 0.3 mg subcutaneously every 20 minutes for 3 doses.	Inhaled beta ₂ -agonist preferred.
<i>Terbutaline</i>	(0.1%) 1 mg/mL solution for injection in 0.9% NaCl.	Subcutaneous 0.01 mg/kg up to 0.3 mg every 2-6 hours as needed. Intravenous 10 µg/kg over 10 minutes loading dose. Maintenance: 0.4 µg/kg/min. Increase as necessary by 0.2 µg/kg/min and expect to use 3-6 µg/kg/ min. ²⁹	Inhaled beta ₂ -agonist preferred.

Figure 9

Dosages of Drugs in Acute Exacerbations of Asthma in Children (continued)

Drug	Available Form	Dosage	Comment
Methylxanthines			
<i>Theophylline</i>	Aminophylline (80% anhydrous theophylline)	Loading dose: * If theophylline concentration known: every 1 mg/kg aminophylline will give 2 μ g/mL increase in concentration. Loading dose: * If theophylline concentration is unknown: —No previous theophylline: 6 mg/kg aminophylline —Previous theophylline: 3 mg/kg aminophylline Constant Infusion Rates: * Infusion rates to obtain a mean steady-state concentration of 15 μ g/mL: <i>Age</i> 1-6 months 6 mo-1 year 1-9 years 10-16 years	
Outpatients:	Oral prednisone, prednisolone, or methylprednisolone	1-2 mg/kg/day in single or divided doses.	Reassess at 3 days as only a short burst may be needed. No need to taper dose.
Emergency Department or hospitalized patients:	Methylprednisolone I.V. or P.O.	1-2 mg/kg/dose every 6 hrs for 24 hrs then 1-2 mg/kg/day in divided doses q 8-12 hours.	Length depends on response. May only need a few days.

*Check serum concentration at approximately 1, 12, and 24 hours after starting the infusion.

All patients admitted to intensive care units should have consultation with an asthma specialist. Consultation should also be considered for patients with multiple hospital admissions.

Patient discharge

From the emergency department

- Release of the patient from the emergency department depends on the patient's response to treatment (see Charts 9 and 11).
- In general, consider patients for hospitalization if their PEFR or FEV₁ remains less than or equal to 40 percent of predicted (or of the best value at baseline) or if the PEFR or

FEV₁ is greater than 40 percent but less than 70 percent when the following factors pertain: persistent severe symptoms; past history of severe asthma; prolonged increase in asthma symptoms prior to the emergency department visit; use of multiple antiasthma medications, especially of systemic corticosteroids, at the time of the exacerbation; inadequate access to medications and medical care; poor home situation; or comorbid psychiatric illness.

- Avoid prolonged (more than 4 hours) detention of asthma patients in the emergency department awaiting a good response to

treatment. Extended treatment in a holding area or overnight unit with sufficient monitoring and nursing care may be appropriate.

- For patients with a rapid response, require a 30- to 60-minute period of observation after the last dose of bronchodilator to ensure stability of response before discharge to home.

At emergency department discharge

- Prescribe, at a minimum, a 3- to 5-day treatment regimen for the patient to continue after discharge. For all patients with a PEFR or FEV₁ less than 70 percent, for all patients at high risk for asthma-related death,

and for many others this regimen should include a course of oral corticosteroids to reduce the rate of recurrent severe asthma symptoms and to treat the underlying pathology of the exacerbation.²²

- Emphasize the need for continuous, regular care in an outpatient setting. A followup medical appointment is necessary to ensure complete resolution of the exacerbation and to review the long-term medication plan.
- Consider issuing a peak flow meter and providing patient education on how to make and record daily PEFR measurements.
- Review discharge medications and, where appropriate, provide patient education on avoidance of asthma triggers.

From the hospital

- Prior to discharge, the patient's medication must be adjusted to an oral and/or inhaled regimen. The optimal timing of this transition is not precisely established, but the general approach is to wait until the patient is minimally symptomatic from asthma and has no or minimal wheezing on chest examination. Usually this clinical status corresponds to a PEFR or FEV₁ value between 60 and 70 percent of predicted (or of the best value at baseline).
- During the first 24 hours after this medication adjustment, observe patients for possible deterioration. Changing from intravenous to oral corticosteroids may involve a significant dose reduction.
- Discharge most adult patients and children over 5 years old with a beta₂-agonist bronchodilator by metered-dose inhaler or dry powder inhaler or compressor-driver nebulizer, to be used no more than every 3 or 4 hours. Confirm the patient's ability to maintain good lung function.

- Prior to discharge, confirm the adequacy of arterial oxygen saturation while breathing room air for patients who received supplemental oxygen during their hospitalization. The preferred method of measurement is pulse oximetry.
- Initiate inhaled corticosteroids at the first followup visit during the prednisone taper. Alternatively, begin inhaled corticosteroids along with the oral corticosteroid therapy prior to discharge from the hospital; this approach may enhance patient adherence.
- For the recommended oral dose of theophylline, see the dosage tables (Figures 8 and 9).
- Provide patient education:
 - Educate patients about their discharge medications and the importance of a followup medical visit in an outpatient regular-care setting.
 - Educate patients over 5 years of age in the use of peak flow meters to monitor their lung function at home.

Management of Exercise-Induced Asthma

Exercise-induced asthma (EIA)—which untreated can limit and disrupt normal lives—is the term for airway narrowing that occurs minutes after the onset of vigorous activity. Exercise-induced asthma should be anticipated in all asthma patients; most have the airway hyperirritability that leads to this condition. For some patients, exercise is the only trigger for asthma. However, these people should be monitored regularly to ensure that they have no symptoms of asthma or reductions in PEFR between exercise periods because symptoms with exercise are often markers of an underlying asthma management problem. Chart 14 presents an overview of EIA.

Diagnosis. A history of cough, shortness of breath, chest pain or tightness, wheez-

ing, or endurance problems during exercise suggests exercise-induced asthma. An exercise challenge can be used to establish the diagnosis. It can be conducted as a challenge in a formal laboratory setting or as a free run challenge. It can also consist of a challenge in which the patient undertakes whatever task caused the problem. A 15 percent decrease in PEFR or FEV₁ (measurements taken pre- and post-exercise at 5 minute intervals for 20 to 30 minutes) is compatible with EIA.

EIA is caused mainly by smooth muscle constriction. It is thought to be a result of loss of heat or water or both from the lung during exercise because of hyperventilation of air that is cooler and drier than that of the respiratory tree.^{1,2} Exercise-induced asthma generally reaches its peak 5 to 10 minutes after stopping the vigorous activity and usually resolves in another 20 to 30 minutes.

Management strategies. The goal of management is to enable patients to participate in any activity they choose without experiencing asthma symptoms. EIA is a condition that should limit neither participation nor success in vigorous activities.

Inhaled beta₂-agonists used 5 to 60 minutes before exercise are helpful for up to several hours. This will prevent EIA in more than 80 percent of EIA patients.³ Cromolyn sodium is also acceptable. Patients who experience a refractory period during continuous exercise may benefit from a warmup period before exercise and may not need repeated medications.

Children who are 5 years and over may be able to use a metered-dose inhaler with a spacer device. Younger children may use a home nebulizer. For those who do not have home nebulizers, oral liquid beta₂-agonist given 30 minutes before exercise may be helpful.

Teachers and coaches need to be notified that a child has EIA, that the child should be able to participate in activities, and that the child may need to use an inhaled medication before activity.

Exercise-Induced Asthma

Clinical Characteristics

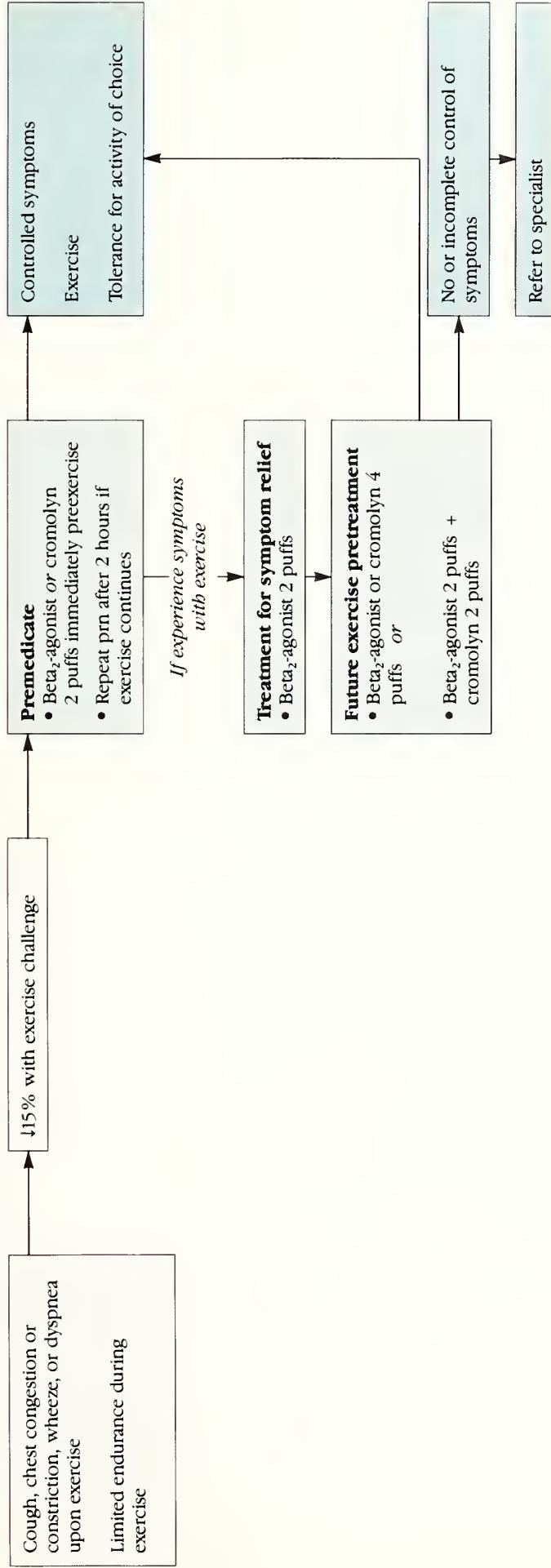
Cough, chest congestion or constriction, wheeze, or dyspnea upon exercise

Limited endurance during exercise

Assessment of Lung Function (PF or FEV₁)

↓15% with exercise challenge

Therapy *



*All therapy must include patient education about prevention (including environmental control where appropriate) as well as control of symptoms.

Component 3

Environmental Measures to Control Allergens and Irritants

The association of asthma and allergy has long been recognized. Between 75 and 85 percent of patients with asthma are reported to have positive immediate skin test reactions to common inhalant allergens.¹ Although these figures probably overestimate the number of patients with asthma in whom allergic factors are important, they do emphasize that allergy must be considered in both the diagnosis and treatment of asthma.

An allergic reaction in the airways is significant. It can cause an immediate response, with bronchial obstruction. It can also precipitate a response several hours after the initial exposure. This late response is associated with increased airway hyperresponsiveness that can persist for several weeks or longer after a single exposure.²

Diagnosis

In diagnosing whether a patient's asthma has a significant allergic component, a thorough history is essential. The checklist in Figure 10 provides a questionnaire for determining relationships between exposure to an allergen and the occurrence of symptoms. Skin tests, which can determine the presence of allergy to specific agents, should be considered for patients with asthma symptoms of at least moderate severity. Clinical sensitivity to an aeroallergen is rare in the absence of a positive skin test. Nevertheless, many positive skin tests do not have clinical relevance because the synthesis of IgE is not unique to clinically allergic individuals. In vitro tests, which yield the same information as skin tests, may also be used, but they are usually less sensitive and more expensive. Any allergy testing should be conducted by the clinician who will interpret the results in the context of the medical history and physical examination, and who will recommend appropriate therapy.

In infants, allergens usually play a less important role in asthma, with viral respiratory infections acting as the principal triggers. In children, the severity of asthma correlates with the number of positive immediate skin tests. The important allergens for children and adults appear to be those that are inhaled. Foods are not common asthma triggers.

Management

To prevent allergic reactions in asthma patients, environmental control measures to reduce exposure to indoor and outdoor allergens and irritants are essential.

Avoid outdoor allergens, primarily ragweed,³ grass,⁴ pollens, and molds.⁵

Exposure to outdoor allergens is best reduced by staying indoors, with windows closed, in an air-conditioned environment,^{6,7} particularly during the midday and afternoon when pollen and some mold counts are highest.

Eliminate indoor allergens, primarily house-dust components and indoor molds.

House-dust components: House dust itself is not an allergen. However, there are allergic components of house dust that should be avoided.⁸

—**Animal allergens.** All warm-blooded pets, including small rodents and birds, produce dander, urine, and saliva that can cause allergic reactions. To eliminate

Figure 10

Patient Interview Checklist for Assessing the Possible Role of Allergy in Asthma

- Is asthma worse in certain months? If so, are there symptoms at the same time of allergic rhinitis—sneezing, itching, nose runny and obstructed at the same time? (pollens and outdoor molds)*
- Do symptoms appear when visiting a house where there are indoor pets? (animal dander)
- If there are pets in the patient's home, do symptoms improve when the patient is away from home for a week or longer? Do nasal, eye, and chest symptoms improve? Do the symptoms become worse the first 24 hours after returning home? (animal dander)
- Do eyes itch and become red after handling the pet? If the pet licks the patient, does a red, itchy welt develop? (animal dander)
- Do symptoms appear in a room where carpets are being vacuumed? (animal dander or mites)
- Does making a bed cause symptoms? (mites)
- Do symptoms develop around hay or in a barn or stable? (molds and mites)
- Do symptoms develop when the patient goes into a damp basement or a vacation cottage that has been closed up for a period of time? (molds)
- Do symptoms develop related to certain job activities, either at work or after leaving work?
- If symptoms develop at work, do they improve when away from work for a few days?

*Possible causes of symptoms are enclosed in parentheses.

exposure, the animal(s) and products made from feathers must be removed from the house, or at the very least kept out of the allergic person's bedroom, in which any central heating and cooling system ducts must also be sealed.

—**House-dust mites.** These mites depend on atmospheric moisture and human dander for survival and appear to have a major role in allergic asthma. High levels of mite antigen are found in dust from mattresses, pillows, carpets, upholstered furniture, bed covers, clothes, and soft toys. Eliminating mite exposure not only reduces asthma symptoms but also reduces levels of nonspecific bronchial hyperresponsiveness.^{9,10} Figure 11 lists measures for controlling house-dust mites.

—**Cockroach allergen.** Roach control benefits asthma patients.¹¹

■ **Indoor molds:** These are particularly prominent in humid environments.¹² Bathrooms, kitchens, and basements require adequate ventilation and frequent cleaning. Dehumidifiers, with the humidity level set for less than 50 percent but above 25 percent, are helpful in damp basements. Perspiration absorbed by foam pillows may encourage mold growth; pillows need to be encased, or changed yearly.

In giving advice on controlling indoor allergens, clinicians should consider the following:

■ **Air conditioning** is a particularly beneficial type of climate control because it allows windows and doors to stay closed and also reduces indoor humidity.

■ **Indoor air-cleaning** devices may be useful, but most important is controlling the source of allergens. However, mechanical filters (the high-efficiency particulate air or HEPA filter is most effective) and electrical filters (the electrostatic precipitator is most effective) can be used within central heating and cooling system ducts or as free-standing units. The clean air delivery rate and the specific aeroallergens to which the patient is sensitive are factors to consider before investing in these devices.

■ **Vacuum cleaners** tend to mobilize fine respirable allergens (including house-dust mites), and allergic patients should not use these cleaning tools. Alternatively, they should use a dust mask, a central cleaner with the collecting bag outside the home, or a cleaner fitted with a HEPA filter.

■ **Humidifiers** are potentially harmful if not cleaned properly and often because they can harbor and aerosolize mold spores. In addition, increased humidity may encourage production of both mold and house-dust mites.

Avoid indoor irritants. There are components of indoor air other than allergens that may be harmful to asthma patients and should be avoided because they may irritate the lung and trigger asthma exacerbations. These include tobacco smoke, smoke from wood-burning heating stoves, strong odors and sprays, and air pollutants, particularly such oxidants as ozone and sulfur oxide.

Immunotherapy. When avoiding allergens and irritants is not possible, and when appropriate medication fails to control symptoms of allergic asthma, referral for allergy immunotherapy should be considered. Allergy immunotherapy has been shown to reduce the symptoms of asthma with a variety of allergens, including house-dust,¹³ cat dander,^{14,15} grass pollen,⁴ and alternaria.¹⁶ Allergen immunotherapy prevents the development of allergic inflammation and perhaps the resulting bronchial hyperresponsiveness.³ Although scientific data are lacking to specify the timing of treatment, it is generally recommended that if patients' symptoms improve, monthly treatment should continue for 3 to 5 years; if there is no improvement following two allergy seasons after reaching the maintenance levels of immunotherapy, it should be discontinued. Allergy immunotherapy should only be administered in a physician's office where facilities and trained personnel are available to treat any life-threatening reaction that can (but rarely does) occur.

Figure 11 House-Dust Mite Control Measures

Essential:

- Encase the mattress in an airtight cover.
- Either encase the pillow or wash it weekly.
- Wash the bedding in water of 130°F weekly.
- Avoid sleeping or lying on upholstered furniture.
- Remove carpets that are laid on concrete.

Desirable:

- Reduce indoor humidity to less than 50%.
- Remove carpets from the bedroom.
- Use chemical agents to kill mites or to alter the mite antigens in the house.

Component 4 Patient Education

Patient education is a powerful tool for helping patients gain the motivation, skill, and confidence to control their asthma.^{1,2} Patient education should begin at the time of diagnosis and be integrated with continuing care. All members of the health care team should participate in the process.

Building a Partnership

Much of the day-to-day responsibility for managing asthma falls on the patient and the patient's family. Active participation by the clinician, the patient, and the patient's family in a partnership can improve patient adherence to the treatment plan and stimulate improvements in asthma management.^{3,4} The partnership concept includes open communication, joint development of a treatment plan by the clinician and patient, and encouragement of the family's efforts to

improve prevention and treatment of the patient's symptoms. An important step in building the partnership is to ask questions early in each patient visit to identify the patient's main concerns about and expectations for treatment. Patients can focus fully on the clinician's recommendations only after these have been addressed.⁵

The Content of Teaching

Patient education involves helping patients understand asthma, helping patients learn and practice the skills necessary to manage asthma, and supporting patients for adopting appropriate asthma management behaviors and adhering to the treatment plan. Providing information contributes to but is not enough by itself to accomplish these objectives. Developing the patient's asthma management skills as well as the patient's confidence that the patient can control asthma is also required.

The full report, *Guidelines for the Diagnosis and Management of Asthma*, presents a complete discussion of suggested patient education programs and provides sample handouts. Areas and topics to be considered in patient education for asthma include:

■ **Definition of asthma** (with an emphasis on the chronic nature of asthma and goals of therapy)

■ **Key points about signs and symptoms of asthma** (the main symptoms of acute asthma episodes, the variability of symptoms among patients, the need to recognize and treat even mild symptoms, the importance of PEFR measurements in detecting early symptoms)

■ **Characteristic changes in the airways of asthma patients and the role of medications** (inflammation, bronchospasm, and excessive thick mucus; inhaled steroids, cromolyn, and bronchodilators)

■ **Asthma triggers and how to avoid or control them** (allergens and irritants, viral respiratory tract infections, and exercise)

■ **Treatment** (the need for individualized continuing care, adverse effects

and how to reduce them, the need for preventive treatment, the importance of early treatment of acute episodes)

■ **Patient fears concerning medication** (Responses to common fears include the following: inhaled steroids are safe and efficacious; toxicity effects can be minimized by reducing the dosage; asthma medications are not addictive; continuous use does not reduce effectiveness.)

■ **Use of written guidelines** (including medication plans for maintenance therapy and managing exacerbations as well as criteria for detecting onset of symptoms, initiating treatment for acute episodes, seeking emergency care, and recognizing when long-term treatment is less than optimal)

■ **Use of written diaries** (to record asthma triggers, symptoms, actions taken, and PEFR in order to see patterns and report to the clinician)

■ **Correct use of inhalers**

■ **Criteria for premedicating to prevent onset of symptoms** (before exercise, before exposure to allergens, cold air, or irritants)

■ **Optimal use of home peak expiratory flow rate monitoring** (to help decide when to initiate or terminate treatment, when to seek emergency care, or when to consider additional chronic treatment because of, for example, high variability in PEFR readings or evening dips below morning PEFR levels)

■ **Evaluation of results of treatment plan** (Review whether the goals of therapy are being achieved; identify any adherence problems in order to overcome barriers or to negotiate changes in the treatment plan. Adherence to the treatment plan is enhanced when the plan is simplified as much as possible and when the plan considers both the patient's ability to afford the medications and the payment method.)

■ **Fears and misconceptions** (Asthma is not caused by psychological factors; most deaths are related to undertreatment and are rare in children; people with asthma should live full and active lives; with proper treatment asthma does not lead to permanent lung disability.)

■ **Family understanding and support** (need for family education about asthma, need for help in managing an acute exacerbation)

■ **Communication with the child's school** (by parents and by the clinician)

■ **Feelings about asthma** (need for acknowledging negative feelings and their validity; possible need for obtaining referrals to self-management programs, counseling, and social services).

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3 Special Considerations

The full report, *Guidelines for the Diagnosis and Management of Asthma*, discusses considerations to be made in treating special groups of patients. These considerations are presented here in brief.

Patients at Risk for Asthma-Related Death

The mortality rate for asthma has increased over the last decade. Although the possibility of asthma-related death exists for all patients with asthma, several studies have revealed that the following factors are associated with an increased risk of asthma-related death:

■ Previous life-threatening exacerbations of asthma or recent hospitalization or emergency department visits (see page 23).

■ Ethnicity. Data show that among African Americans the asthma death rate for all ages is almost three times higher than among Caucasians. In younger age groups—15 to 44 years of age—the death rates for African Americans are nearly five times higher, particularly from urban areas.¹³

■ Lack of adequate and ongoing medical care that provides appropriate followup and preventive therapy.

■ Significant depression and/or psychosocial behavioral problems.⁴

The greatest threat to the high-risk individual with asthma, however, is complacency or underestimation of the severity of the disease on the part of the patient, the patient's family, the physician, and/or the medical care system.

Pregnancy and Asthma

Maintaining sufficient lung function and blood oxygenation to ensure adequate oxygen supply to the fetus is essential. Poorly controlled asthma during pregnancy can result in increased perinatal mortality, increased prematurity, and low birth weight.⁵ For most drugs used to treat asthma and rhinitis, with the exception of alpha-adrenergic compounds, brompheniramine, and epinephrine, there is little to suggest an increased risk to the fetus.^{6,7,8} Other

classes of drugs with some possibility of risk to the fetus include decongestants (oral alpha agonist), antibiotics (tetracycline, aminoglycosides, sulfonamides, and ciprofloxacin), live virus vaccines, immunotherapy, iodides, and alpha-adrenergic compounds.

Surgery and Asthma

Asthma patients are at risk for specific complications during and after surgery: acute bronchoconstriction triggered by intubation; hypoxemia and possible hypercapnia; impaired effectiveness of cough; and atelectasis and respiratory infection.⁹ The likelihood of these complications depends on the severity of the patient's airway hyperresponsiveness, the degree of airflow obstruction, and the amount of excess airway secretions at the time of surgery. Optimizing the patient's lung function prior to surgery and maintaining daily asthma medications are important management strategies.

Older Patients

Asthma-related deaths are highest among people 55 years of age and older. Careful evaluation is required because the precise cause of severe airflow obstruction can be difficult to identify in older patients with asthma. Oxygen therapy in acute exacerbations must be used cautiously. Medications employed for other diseases may aggravate asthma,¹⁰ as in the case of nonsteroidal anti-inflammatory agents for treating arthritis or nonselective beta blockers for treating hypertension, or beta blockers found in some eyedrops. Theophylline and epinephrine may exacerbate underlying heart conditions.

Occupational Asthma

An estimated 2 percent of all asthma may be caused by exposure to specific sensitizing substances at the worksite. Early diagnosis is important and eliminating exposure is a preferred treatment because once sensitization has occurred, bronchoconstriction will often be triggered by minimal subsequent exposure, and because once well established, occupational asthma may not be completely reversible.^{11,12,13}

Rhinitis, Sinusitis, and Nasal Polyps

Maintenance of nasal patency and function will probably lead to more effective asthma control.^{14,15} This is accomplished by restoring patency (with oral and topical nasal decongestants or corticosteroids or cromolyn sodium nasal spray), controlling nasal secretions (with antihistamines or topical nasal corticosteroids), treating sinus infections (with antibiotics and treatment for nasal mucosal edema), and managing nasal polyps (with topical nasal corticosteroids).

Aspirin Sensitivity

From 5 percent to 20 percent of adults with asthma will experience severe and even fatal exacerbations of asthma after taking aspirin or certain other nonsteroidal anti-inflammatory drugs. The prevalence increases with increasing severity of asthma.¹⁶ Further, many patients with aspirin sensitivity also have nasal polyps, although this is probably not a causal relationship. All patients with asthma should avoid this group of medications and instead use such usually safe alternatives as acetaminophen, sodium salicylate, or disalcid.

Sulfite Sensitivity

Sulfiting agents, which are used to preserve foods and beverages, have caused many severe and even fatal asthma exacerbations.¹⁷ Although the Food and Drug Administration has banned the use of sulfites on "fresh" fruits and vegetables, sulfites may still be found in processed potatoes, shrimp, dried fruits, and beer and wine. In addition, sulfites are present in nebulized beta₂-agonists, although injected solutions pose little or no risk.

Tartrazine Sensitivity

The yellow dye tartrazine, commonly employed in food and medication, has been linked in some reports with occurrences of acute bronchoconstriction.¹⁸ However, the incidence is very low, and such reactions are probably limited to those rare individuals who appear to have an immunologically mediated sensitivity to the dye.

Gastroesophageal Reflux

The relationship of asthma to gastroesophageal reflux remains a matter of debate, although it is nearly three times as prevalent in both children and adults with asthma.¹⁹ Most of these patients also have a hiatal hernia. Medical management includes eating smaller but more frequent meals; avoiding food or drink between dinner and bedtime; avoiding fatty meals, spices, ethanol, and theophylline; using H-2 antagonists; using drugs that increase lower esophageal pressure; and elevating the head of the bed. Surgery is reserved for severely symptomatic esophagitis and is not successful for everyone.

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